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THE TIDE OF ARMAMENTS

LORD ISMAY has prepared a lively account of a lively alliance. As Secretary General of the North Atlantic Treaty Organization he describes how Western Europe and North America steadied the sudden pendulum swing towards disarmament which took place immediately after the war, and how, in the space of five years, the abilities and efforts of the member states have been concerted for the common good of nearly 400 million people.* Military problems predominate, but NATO also works in the political, economic and social fields. Thus, positive collective action in these fields raises the prudence of defence above the level of mere insurance, however astronomical in scale, and renders it worth-while in human terms.

Look at a plan of the Northern Hemisphere in which the North Pole is the centre, and see how a Great Circle through the Pole almost exactly divides the states into the two Twentieth Century power groups. It may be cause for recrimination that science and engineering have been responsible for this division of the world, but equally one may reflect hopefully that two world camps are the nearest that mankind has come to universal brotherhood.

The state of military aircraft production in 1948 was typical of the run-down in armaments which took place after the war. Apart from work on a few prototype machines there was virtually no production of front-line aircraft in continental Europe. No jet engines of any type and almost no aeronautical instruments were being manufactured. Only in the United Kingdom were production lines still active. But in the following years production was stepped up and arrangements were made for various countries to build engines and aircraft under licence. World economic conditions imposed a severe strain on the NATO countries who were endeavouring to play their part. The difficulty has been overcome by aid from North America and by co-ordinating national arms programmes. Member nations have been brought together at the technical level in joint studies and in the interchange of information. To quote one example—the Advisory Group for Aeronautical Research and Development (AGARD), consisting of representatives from each NATO country, have studied and exchanged information on the operation of jet engines at high altitudes, on wind tunnels, and on medical science in relation to high-speed flight. In this and other fields the frustrating secrecy imposed by national security regulations has been appreciably lessened.

Throughout Western Europe enormous efforts have been expended on building NATO airfields, military communications equipment, fuel tanks and pipelines, radar warning and navigational aid stations, port installations, and military headquarters. Work of this kind is known as "common infrastructure," using the French word for the work that is necessary before a railway track can be laid. In NATO parlance infrastructure denotes all the fixed installations required for the effective deployment and operation of modern armed forces. Up to July 1, 1954, the expenditure of £700 million had been approved. In three years the number of airfields ready for use rose from 15 to 125, and 40 more are expected to be completed this year. By the end of this year, too, 10,000 km. of radio relay circuits, 16,000 km. of land lines and 1,700 km. of submarine cable will have been added to existing civilian networks. To supply jet aircraft with fuel—a task to which conventional transport by road and rail is quite unequal—a European system consisting of 6,100 km. of pipelines and 1,283,000 cubic metres of storage tanks will be built by the end of 1956.

In five years the people of the NATO countries have devoted a large slice of their energies to mutual defence. To that extent they have accepted a lower standard of living, and a reduced investment in future civilian enterprises. They have also reduced their ability to help the less fortunate nations of the world. Between 1949 and 1953 their combined defence budgets rose from 18,500 million dols. to nearly 62,800 million dols. annually. Everyone hopes that the effectiveness of this vast expenditure will never be put to the test of total war. But it must be judged now, and always, on its probable effectiveness in the event of war. The outcome would depend very largely on the speed with which the work of present armaments firms could be multiplied by the additional effort of all industry. Experience has shown that this is a maddeningly slow process. With modern weapons it would be even slower. Lord Ismay's report states that "particular importance is attached to building up in Europe a sound industrial base from which output of military equipment could be rapidly expanded in an emergency," but in an otherwise reassuring report this fails to convey the impression that the NATO staff have studied the problem sufficiently deeply. Some means should be found of enabling selected engineers who are not normally engaged on armaments to study the problems that would face them in war. Even a week-end course once a year would be better than nothing.

* *NATO: The First Five Years*, 1949-1954.

Weekly Survey

"FLYING BEDSTEAD"

Many readers of ENGINEERING will by now have seen the short film, released last week, of the "Flying Bedstead"—the Rolls-Royce vertical take-off research machine—in free flight, and will have been impressed by its steadiness and controllability under the compressed-air jet controls. At the time that the film was taken, the weather was not perfect, but the machine rode happily through 15-knot gusts. A brief description of the Flying Bedstead was given in the October 1, 1954, issue of ENGINEERING and no further technical data have been released.

The vice-chairman of Rolls-Royce Limited, Mr. A. G. Elliott, C.B.E., has, however, made a statement on the potentialities of vertical take-off jets. They are intended solely for launching an aircraft into the air and for landing without the necessity for a runway, and will probably not be used for more than two minutes or so during each flight. It is not, apparently, feasible to call upon the main propulsion engines for vertical lift, and so separate take-off jet engines will be carried in the aircraft. Since the take-off jet requires to operate only at maximum r.p.m. and over a limited range of altitude, the design can be simplified and the specific weight can be kept extremely low.

Aircraft utilising vertical take-off jets will clearly have to be designed specifically for the job. It is claimed by Rolls-Royce that, in spite of the additional weight and space requirements of engines that will be passengers during the major portion of the flight, an overall weight saving and enhanced performance can be achieved since, by the elimination of the take-off and landing runs, radical design changes will be possible. They envisage, for example, simplified undercarriages and extremely high stalling speed.

It is not surprising to learn that Rolls-Royce consider that an air-liner constructed on these principles will not be a commercial proposition for at least 15 years. In fact there is, on the basis of present knowledge available to the public, some difficulty in visualising that it will ever be an economic proposition. It cannot be doubted, however, that the vertical take-off research project will furnish extremely valuable data on new methods of control.

* * *

MACHINE TOOLS

The rapid decline in the order book of the machine tool industry in 1953 naturally gave rise to fears about the future, not only for manufacturers of machine tools, but for the British engineering industry as a whole. Fortunately, these fears have been greatly allayed by a rapid flow of orders in recent months. As the article on the machine tool industry in the ENGINEERING Outlook series (page 140) shows, the volume of new orders being received is once more exceeding deliveries: in the third quarter of 1954 new contracts valued at £20·2 million were booked compared with deliveries of £15·0 million, and the total order book by the end of last year was equivalent to well over a year's production.

Particularly encouraging has been the revival of export orders, which now amount to £24 million; this should end the persistent decline of export deliveries over the past few years. The revival, however, is due very largely, though not exclusively, to the acceptance of big Russian orders following the relaxation of the prohibited list. In the six months to November, 1954, 116 applications to export machine tools were granted, involving contracts valued at £11 million, and more are under consideration. It seems, therefore, that (as before the war) Russia will once more become the largest market for British machine tools, and may well account in the next two years for between one-third and one-half of total British exports (which amounted to £20·2 million in 1954). Demand for machine tools in Russia has changed somewhat in character as compared with prewar. The Russians now have a large machine-tool industry of their own, and demand is not now for large numbers of simple standard tools but for comparatively few large, complex and expensive machines. Demand for standard types of machine tools abroad continues to be somewhat disappointing. Many of the less industrialised countries, such as the South American countries, where they might be expected to be in demand, are embarrassed by currency difficulties.

At home, demand for the simpler types of standard tools has also been the least satisfactory—although it too has recovered substantially in recent months. The main pressure has been for the heavier and more complex types—particularly "specials" for heavy electrical engineering, locomotive builders, and, above all, for the large unit mass-production machines used by the motor-vehicle industry. It follows that the revival in orders for machine tools is due largely to those sections of the engineering industry which are benefiting from the heavy public investment programmes in electricity, steel and (perhaps) rail transport, or to those like the motor-vehicle industry which are enjoying an extremely buoyant demand for their products. In many sections of the engineering industry where the need for new equipment is imperative if ground is to be maintained in competitive markets, the response to the investment allowances in the last Budget is still disappointing. As far as the machine-tool industry is concerned, however, the future is bright: the number and extent of factory building schemes licensed is a record and it will be at least two years before these are translated into deliveries of machine tools. When order books are thus loaded, it is important that customers should give the earliest possible notification of their requirements. Delays by the motor industry in defining their needs are embarrassing the industry.

* * *

OUTLOOK FOR CANADA

Growing steadiness, rather than renewed expansion, during 1955 is suggested by the Canadian statistics for 1954. During the second half of the year production and employment have continued to run somewhat below the level of 1953, but the decline appears to have been arrested. The publicity given to spectacular capital projects such as the extension of the Kitimat aluminium plant, the Quebec-Labrador iron-ore development, the St. Lawrence seaway project and the Trans-Canada Pipeline has tended to obscure the substantial decline that has taken place in manufacturing and agriculture. The contraction of activity, which has been paralleled by reduction of imports, has been most marked in textile production, and the output of almost every type of engineering product. There are several reasons for this, ranging from a marked fall in advance orders and reduction of stocks to increased competition from imports which has forced prices down. There is little doubt that during a U.S. recession, however mild, that country's manufacturers intensify their sales effort in Canada and are willing to cut prices to secure a high volume of sales. The November issue of the *Bulletin* of the Bank of Nova Scotia points out that the metal industries have been affected "by the overtaking of accumulated demands for industrial equipment and for such consumer goods as automobiles and household appliances."

Canadian car output, which was at full capacity during the first four months of the year, fell to less than half the 1953 level during the third quarter "despite widespread price cutting by dealers," and output during the year is likely to be 15 to 20 per cent. lower. Output of refrigerators during the first half of the year was 6 per cent. lower in 1954 than in 1953, and that of washing machines 20 per cent. lower. Despite these falls in the output of durable consumer goods, the level of consumer expenditure remained very high. Expenditure on "service industries" (including every consumer service such as retail stores, banks, telephones, laundries, etc., which together account for about half the total Canadian national income) continued to rise despite unemployment and a sharp reduction in farmers' incomes. Although most of the increase in consumer expenditure was on food, sales of cars began to increase towards the end of the year, doubtless stimulated by the appearance of new models, and there was a slight recovery in the sales of household appliances. The demand for houses, which lagged somewhat in the beginning of the year, recovered quickly and rose to higher levels as soon as the Government introduced easier financial arrangements and the total expenditure on house construction is expected to be the highest ever, some 6 per cent. above the 1953 level.

The economy is therefore being sustained by heavy consumer spending and this will doubtless, in turn, stimulate demand for capital goods. It is unlikely, however, that a full recovery will be made this year. The employment in metal-using industries, other than those engaged in the production of consumer durable goods, was 10 to 15 per cent. lower than in 1953, and there is a great deal of leeway to make up. While it is difficult to assess the extent of the recovery likely to take place in 1955—one most favourable factor is the low level of stocks of practically every type of goods—it is probable that the recovery will be in step with that in the United States, though perhaps lagging behind somewhat. The outlook for British exports of engineering products to Canada is thus not wholly favourable, but they should none-the-less increase a little.

* * *

MORE ORDERS FOR SHIPS

The latest Lloyd's Register Shipbuilding Returns do not record the great improvement which has taken place in the affairs of shipbuilders in the past three months. The total tonnage for which plans had been approved or material ordered at December 31, 1954, had sunk to not much more than half the peak level of 1952 (1·49 compared with 2·68 million tons) and had fallen by nearly a third compared with December, 1953. Meanwhile, of course, better supplies of steel have meant greatly increased activity in the yards, and 1·4 million tons were launched in 1954 compared with 1·3 million tons in 1953.

The continuation of these trends would have meant the rapid exhaustion of order books, but fortunately there has been a flood of orders in recent months, the effect of which should be apparent in the Lloyd's Returns for the current quarter. British yards have, however, received proportionately fewer of the new orders than their foreign competitors. Japanese and Italian shipbuilders have benefited most, largely because the state of their order books enabled them to promise very speedy delivery. In particular, large American orders have been placed in these countries. According to the recent statement of the President, Mr. Walter L. Green, at the annual meeting of the American Bureau of Shipping, of 164 vessels being built to the classification of the Bureau abroad, 32 are in Japan, 14 in Trieste and 20 in Italy—compared with 13 in the United Kingdom. As empty berths fill up abroad, the proportion of orders coming to the United Kingdom must, however, steadily improve; and, since there is no exceptional circumstance to account for the orders recently placed, British shipbuilders can presumably look forward to a steady flow of new contracts in coming months.

In the view of the President of the American Bureau of Shipping, "the volume of new orders placed in recent months does not constitute any great rush for new tonnage, such as would be experienced in an emergency. Rather the orders are principally for larger vessels to replace, in many cases, two or three smaller and older ships . . ." It seems, in fact, that shipowners are now reconciled to the present level of freight rates and, recognising that they can still show a profit by operating modern tonnage, are at

last getting on with the job of fleet replacement. American shipowners, who have been as tardy in this respect as the British, have been particularly eager to place orders.

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THE MIDLANDS

Following a year when output in the motor-vehicle industry was a record, with more than a million vehicles, it is not surprising to learn that industrial development has been rapid in the West Midlands. According to figures issued by the Midland Regional Board for Industry, there were 417 applications in 1954 for industrial development certificates for projects covering 9·4 million sq. ft. and requiring the employment of nearly 10,000 workers. This is nearly double the 1953 rate of development, and is due largely to the motor vehicle industry, whose projects will account for nearly 40 per cent. of the total additional employment. Nevertheless, other industries are also participating and the pressure of demand for available building space in the crowded Birmingham and Coventry areas is intense. The situation is complicated by the necessity of redeveloping slum areas in which there are a very large number of small firms. The Birmingham Corporation are tackling this problem resolutely, and have a programme for redeveloping five areas totalling 1,000 acres. It is estimated that eventually 2,000 firms will have to be moved from the older districts of the city. One expedient for making the best use of the available area is the erection of multi-storey factories. Work is to begin on the erection of two such factories for Birmingham Corporation in March, and in a few years' time many of the small firms in the Birmingham area may be housed in seven or eight-storey buildings.

While the prosperity of the Midlands is to be welcomed, the problems encountered there must give rise to doubts about the effectiveness of present policies for securing the optimum distribution of industry in the United Kingdom. Whereas in the Birmingham area, despite the swollen state of the population and overcrowding, labour is scarce, there is serious unemployment in Northern Ireland. In Scotland, where most manufacturers anxious to expand would be able to find suitable labour, the flow of industry into at least one of the new towns has been disappointing. The Government has, of course, exerted a very real and healthy influence on the distribution of industry in the past few years, and the problem is not one which can be solved quickly or easily. Nevertheless, it is worth inquiring whether there is not scope for hastening improvement—for example, by greater capital expenditure on improving communications in the areas where industrial development has been disappointing.

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STORAGE HEATERS

The electrical supply industry, unlike the gas industry, still lacks effective direct means of large-scale storage of surplus energy, except by means of expensive and heavy storage batteries, now outmoded on anything like a national scale by the almost universal alternating-current supply system. Unless the recently described experimental "fuel cell" can be developed for economical large-scale operation, direct storage of electrical energy with alternating-current systems still appears to be a remote possibility.

But the indirect electro-thermal storage method has now succeeded in attracting great interest and much useful business with certain of the Electricity Authority's Area Boards, and appears likely to spread on a country-wide scale. Electro-thermal storage was developed many years ago in the form of large-scale hot water systems, as floor heating systems using the floor material as the storage mass or as smaller separate storage heaters of 1-kW to 3-kW ratings using blocks of suitable stone, metal or ceramic as the storage medium. In all these cases the storage principle is the same, namely, that of heating the storage medium during the night hours (usually eight or ten hours as a maximum), starting at midnight or somewhat earlier and finishing before the early-morning peak load at about 8 a.m. A time switch and special meter are usually needed in such circuits.

To make this method attractive to consumers a cheap night tariff must be offered. In pre-war days, on the Continent, this was a well-established practice and electricity for heat storage purposes was available every night at 0·375 pence per unit, and in some towns for less, particularly at week-ends. Stations generating from water power, as in Switzerland, were particularly suitable because their motive power flowed day and night at no cost. In this country, the cost to power stations of coal was so low that it formed only a small part of the cost of a unit of electricity and therefore the British case was comparable with the Swiss. It would appear that the supply authorities here could therefore have adopted the thermal storage principle to advantage at that time, but did not do so, presumably because other forms of electric space heating were booming; the fact that these were used during peak hours did not matter then as plant capacity was adequate and no time switch or extra meter was necessary for such heaters.

In view of the great change which has now occurred in the outlook of the B.E.A. following the well-known restrictions upon supply at peak load times, thermal storage methods are now news of some considerable importance in the electrical world. Moreover, the consumer's electricity bill is favoured sufficiently by the cheap night tariffs offered (of the order of 1·0 pence per unit now as against the 0·375 pence expected in pre-war days) to have started something approaching a boom in the sales of thermal storage units.

The factors involved, including most of those relating to the design of the modern type of unit storage heater, were thoroughly discussed in these pages as long ago as 1931 ("Solid Core Thermal Storage Heating Units," by Dr. L. G. A. Sims and Dr. K. R. Sturley, ENGINEERING, vol. 131, pages 561 and 664, and vol. 133, page 109). These earlier articles described a fully-developed storage unit based upon one of the most successful of the Swiss storage heaters with patented improvements. The progress now occurring in this country (and even more, that in Ireland) will be watched with great interest, and there should be scope for progressive improvement in design of the heaters in the form of weight reduction and constancy of emission temperature.

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THE VOLKSWAGEN FACTORIES

The Volkswagen Company announced last week expansion plans involving the expenditure of about £12 million which will raise capacity to over 300,000 vehicles a year, compared with 254,000 in 1954. Floor space will be increased to about 6 million sq. ft. and the company's branch factory at Stöden, near Hanover, will become the commercial vehicle factory. Daily output is expected to rise from the present 1,060 units to 1,200 at the end of the year. Volkswagen's output in 1954 was by far the largest in Germany. Opel, the General Motors subsidiary, produced about 165,000 vehicles, followed by Daimler-Benz with 63,000 and Ford with 58,000. Volkswagen accounted for about 37 per cent. of total German vehicle output last year, and the expansion programme will enable the company to remain the leading manufacturers, although Opel—who plan an output of 1,000 vehicles a day when their own expansion plans are completed—will run them close.

The Volkswagen Company expect their exports to rise to 165,000 vehicles this year, and say that all their agents abroad have placed firm orders for a full year ahead. About 80 per cent. of exports go to other European countries, but exports to the United States have increased considerably, from 900 cars in 1953 to 8,944 last year, and they are expected to total more than 20,000 this year. This would make the United States market second in importance only to Sweden, where 30,000 vehicles are expected to be sold in 1955 (13,735 last year). The company have established assembly plants in Belgium, Eire, Brazil, Australia, New Zealand and South Africa, with a total capacity of 31,000 cars a year.

A measure of the company's confidence is their statement that they have no intention of reducing prices despite the substantial price reductions announced last month by Ford and Opel. Referring to Opel's large expansion programme, Herr Nordhoff, Volkswagen general manager, said that expansion would continue in 1956 and that "we shall certainly invest no less than other companies which have already announced figures."

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MASS PRODUCTION OF DIESEL ENGINES

The meteoric rise of F. Perkins, Limited, since the war as a major producer of Diesel engines is one of the success stories of British engineering. When the new factory of over half a million square feet was erected in 1947, on a site of 120 acres, few people in the oil-engine industry would have expected the demand for road vehicle and agricultural tractor engines to rise so steeply. In that year, employment at Peterborough was 1,148 and engine production less than 4,000, totalling about 340,000 brake horse-power. Last year, with a staff of 5,296, the number of engines produced had reached 60,048, with a total brake horse-power of 4,461,000. The company have announced extensions to their factory "to accommodate the increasing demand," which will increase the floor area by 140,000 sq. ft.

The progress of Perkins has been based almost entirely on the fact that the modern Diesel engine is considerably cheaper to operate than its petrol equivalent, and on a growing confidence in its reliability. The company's reconditioned engine service and world-wide spares and maintenance organisation helped to foster this confidence. The proportion of agricultural tractors fitted with oil engines rose from 15 per cent. in 1951 to 47 per cent. in 1953, and is expected to be substantially higher now. A similar trend is visible in commercial vehicles and taxis.

At the outset there were heavy purchases by comparatively few manufacturers, mainly of trucks and agricultural tractors. Some of these—the Ford Motor Company, British Motors Corporation, and Rootes—have now developed Diesel engines of their own, and although they continue to fit Perkins engines in vehicles in their range, the company have had to find many new customers to maintain the rate of increase in their output. They now supply 110 manufacturers of industrial plant, commercial vehicles, agricultural equipment and motor boats. The introduction of a larger engine—the R6 developing 108 brake horse-power at 2,700 r.p.m.—has placed them in a very good position to benefit from the rapid increase in the output of trucks of light construction of 7- to 8-ton payload capacity such as are produced at present by Vauxhall, Rootes and Dodge. These trucks have an unladen weight of just over 3 tons, compared with just over 4 tons for trucks of similar load capacity built by Leyland, A.C.V. and other heavy vehicle builders. The rapid introduction of the Diesel engine for taxis, very light commercial vehicles and cars will doubtless provide Perkins with considerable scope for expansion during the next few years. In addition, large numbers of engines continue to be required for conversions of existing trucks from petrol to Diesel.

The outlook for the company, therefore, bids fair, despite increasing competition at home and local manufacture in overseas markets. Only a major change in the price policy of the oil companies or in the Chancellor's taxation policy could slow down the advance of the light Diesel engine, and this would appear, for the next few years at any rate, a most unlikely event.

ORGANISING RESEARCH FOR THE SMALL FIRM

USING TECHNICAL COLLEGE FACILITIES

It has often been said in the past few years that Great Britain must make fuller use of her technical abilities if she is to survive industrially; that she must export a better, more-highly developed product than hitherto if she is to retain her markets overseas; and, moreover, that the better are the products of her industries, the better will be the standard of living of the community. To attain these aims it is evident that the most effective use must be made of all instruments and machinery of research and development. One such source where more research might be undertaken but which is as yet largely untapped is that of the educational institutions: such institutions—universities, technical colleges and polytechnics—are staffed with men well-versed in the fundamentals of engineering science, most are well equipped with standard testing equipment and many have adequate workshops where special equipment could be fabricated for any particular investigation.

The problems involved in effecting co-operation in engineering research between educational institutions and industry—particularly as they were to be found in respect to mechanical engineering—was the subject of a paper* presented by three authors and discussed at a general meeting, arranged in conjunction with the Education Group, of the Institution of Mechanical Engineers, on last Friday, January 28.

In introducing his part of the paper, Professor Giffen emphasised that universities—and in this he included all relevant educational institutions—were looking for research work. This contention was well supported by the fact that his audience consisted almost entirely of university teachers and that, with only one exception, all who took part in the discussion were also from education departments. It was the case, opined Professor Giffen, that total expenditure by Government departments and industry in the mechanical engineering departments did not exceed £¼ million per annum. If it was the complaint of industry that the rate at which research progressed in the universities was too slow, then it could be fairly pointed out that if industry did not pay adequately it was unreasonable to expect rapid progress. If industry did pay for the services that it required, then the labour would be available, but the arrangements for the work had to be on a sound business basis.

Of the value to the education departments of sponsored research, Professor Giffen gave it as his opinion that the teachers would benefit considerably from undertaking this type of work, so long as the amount they were doing did not interfere with their taking an active and effective part in the teaching duties of their department.

In his written contribution to the paper he had already propounded two methods whereby such co-operation in research could be initiated. The first was that an interested company should invite from the universities a list of the research projects they would pursue if adequate funds were available, and then to undertake to support, in an effective way, one or more of these researches. Alternatively, the company would circulate a list of the problems in which they were interested and would support as research projects.

PART-TIME WORK

This second suggestion was mentioned and its value confirmed by Mr. Davies when he introduced his own part of the paper. From 1919 Mr. Davies has been on the staff of the Battersea Polytechnic and from 1935 to 1950 he was head of the department of mechanical and civil engineering; since his retirement from that post he has continued his activities at Battersea as supervisor of research. For many years now, under his direction, the Polytechnic has built up a record of research which is probably unequalled by any comparable institution. In particular a large part of this work has been undertaken on a part time basis either by men doing other work within the department or by men who were following up a problem met in their normal day-to-day duties in industry. In regard to the issue under discussion—that of sponsored research being undertaken by the staff of a company released part time for the project in hand and/or lecturers who would also be otherwise engaged in full time teaching—it was interesting to hear of Mr. Davies' experience that other activities were not necessarily detrimental to the overall rate of progress of the research. This was particularly so when the nature of the work involved short periods of actual observation but required lengthy analysis and interpretation and where familiarity with practical conditions was important.

Another aspect mentioned by Mr. Davies was that of not knowing where any research study might lead. Firms sponsoring research must appreciate that it was inevitable that any project would raise other issues of an equal or of an even greater magnitude and possibly some that would require solution before progress could be made with the main problem. Where firms were deterred from inviting assistance from colleges because, in most cases, the results would be openly published, this difficulty could be overcome by the staff of the firm doing that part of the work which came under the heading of development, while the college staff handled the fundamental part of the work. A greater degree of secrecy could be requested if the firm met the full cost of the work so that no part thereof fell on public funds. This last point had been discussed in Mr. Nixon's contribution to the paper: he had advocated that, in those instances where it was likely that some embargo would have to be placed on the free publication of the results of the investigation, some other means of doing the work should be found.

When making his own introductory remarks, Mr. Nixon emphasised the value of the training that a man received if he undertook, even part-time, a research problem on behalf of his firm at the local technical college. The value of the training in the methods of research and in the greater understanding of the technical problems involved that was thereby attained could outweigh the value of the research as research. It had been found that a man who had had the experience of tackling a problem in such a fashion returned to his duties more able to cope with the every-day problems of design and production.

EXCHANGE OF INFORMATION

There was, however, continued Mr. Nixon, a great need for more channels of information. It was safe to assume that many industrial concerns spend much time and effort in dealing with problems which have been solved elsewhere. A piece of correct information in the right place at the right time could save considerable time and expense and possibly misdirected research. Some form of central office of information was required which could bring together those seeking or finding the same kind of knowledge.

In opening the discussion on the paper, Dr. D. Clayton referred to the importance of the correct and most efficient form of co-operation on research between industry and the colleges. The resources for research were not unlimited; many firms thought that because they had a research department they were being progressive, whereas, unless effective work was being done, they might be robbing the country of the services of very good men. Similarly, some universities kept post-graduate students without regard to their overall value to the community and it was the case that some of them would be more effectively used in industry.

It was the function of the true university research departments, in so far as they should do research at all as opposed to teaching, to do fundamental work, and industry should not ask them to do otherwise. There was a great danger if large sponsored programmes of research were allowed to dominate university activities. Where the problem was one common to their industry, then their own trade research association should be applied to. Where the problem was their own concern, then they could do it themselves, employ an independent research body or ask the local technical college to help them—on a confidential basis if necessary. The great difficulty was that of finding, without the burden of time-consuming visits and of considering too many papers, the department most interested in a particular type of basic problem. There was a real need for a neat answer to this "contact" problem.

The second speaker, Dr. M. R. Gavin, M.B.E., described the organisation that had been built up at his own technical college during the past five years. From next to nothing the expenditure on research had grown to last year's figure of about £16,000, largely contributed by local industry or Government departments. Three conditions were essential if educational institutions were to get research sponsored by outside bodies. They were: first, a willingness to do the kind of research that industry is interested in; second, to have the ability to deal with that kind of problem; third, to have the necessary facilities such as workshops, etc.

COLLEGE ORGANISATION

At Birmingham they were developing an organisation under the direction of a vice-principal whose main extra duties were those of supervising research by being responsible for general co-ordination both inside and outside the college. The actual work was done by the members of the teaching staff who had demonstrated their ability to conduct research. For these people, teaching time was kept down to actual class contact of 10 hours each week. In addition, the college made appointments termed research assistants. These people were paid a Grade A lecturer's salary; they had up to ten hours of class work per week, mainly in laboratories, and the rest of their time was spent in research, mainly for outside bodies. They were all working for higher degrees.

Dr. Gavin ended his remarks by affirming his belief in the overall value of such research to educational establishments. The staff were made to re-examine fundamentals and their whole attitude to teaching was improved. The type of man produced by the college could be influenced very considerably by the right kind of research being done by the college; the better students stayed and took part in the research projects and were thereby trained in research methods. In his view, Industry was justified in supporting research in colleges on those grounds alone.

Mr. H. Addison, who followed Dr. Gavin, drew attention to the considerable amount of civil-engineering research that was undertaken at universities at the request of consultants. He suggested that a study might be made of those special conditions that perhaps made co-operation more difficult in the case of mechanical-engineering research than in that of civil engineering. Mr. Addison also drew attention to the great bulk of material available in post-graduate theses and inquired what means there were for examining these documents. In his later reply to the discussion Mr. Davies took up this latter point and suggested that anybody who had a technical problem would always find it worth while trying to find out whether anything had been published on it as a thesis. Not only did such theses contain specific information on the point directly investigated but they frequently included a very elaborate and careful summary of the whole field leading up to the piece of work.

One aspect of the "contact" problem was developed by Mr. D. B. Welbourn. At Cambridge, they were encouraging graduates to revisit the department on an open day set aside for that purpose so that they might see the work that was being currently undertaken. The annual report of the department of engineering, which included notes on the research in progress, was circulated to all members of the University engineering association. As a result of the open day and of the circulation of the reports many inquiries were being received from those in industry who had found that there was someone at the University who was familiar with the problems that were worrying them. Another way in which the University was helping was by the provision of short courses aimed particularly at giving the graduate in industry an insight into new techniques.

CONCLUSIONS

From the paper and from the discussion it could be concluded that there was available within the United Kingdom a considerable number of university departments and technical colleges where members of the staff were able and willing to undertake work on behalf of industry. It was realised that the main function of the educational institutions was to teach, but it was felt, as Dr. Heywood had said, that all concerned in education would maintain a correct balance between fundamental and sponsored research and would otherwise fulfil their correct function. By a considerable majority, speakers expressed the opinion that research has a beneficial effect on the teaching department as a whole—including the undergraduate who might himself never have to do any research.

Finally, there appeared to evolve out of the discussion a need for a new bureau or clearing house for information and communication between industry and the educational establishments: a bureau which could pass on industry's requirements to the colleges; which could make better known the existence of much of the research which was already being done; and, finally, could and would encourage greater contact between the college staffs and the firms, particularly the smaller firms who employed no qualified staff.

* "Co-operation in Engineering Research between Educational Institutions and Industry"; Part I—by Professor E. Giffen; Part II—by Mr. V. C. Davies; Part III—by Mr. J. H. R. Nixon. See also leading article "Help from the Colleges" on page 65 of our issue of January 21.

Letters to the Editor

METERING PULSATING FLOW

STROUHAL NUMBER AND HODGSON CRITERION

SIR, Dr. J. M. Zarek's painstaking attempt to tackle an important problem referring to pulsating flow surely is welcomed by all concerned with accurate flow measurement. Obviously, in contradistinction to steady-flow problems, some special criterion has to be used as a basis for the analysis of the test results. For this purpose Dr. Zarek introduced a new non-dimensional number, viz.:

$$\frac{L\,\Delta P}{A\,d}.$$

This non-dimensional number should form a model law to make the results adaptable for general applications under similar conditions.

An analysis of the author's new group reveals its composite nature, being a product of the Strouhal number and a dimensionless amplitude ratio. The Strouhal number is

$$\frac{u}{fl}=\frac{L}{d},$$

and the amplitude ratio $\frac{\Delta P}{A}$.

The writer is of the opinion that, with respect to model laws, certain postulates exist which should be considered carefully before any new non-dimensional group is introduced. Two of the most important ones may be expressed as follows: (*a*) The complete system of non-dimensional groups forming the model laws of dynamical similarity in fluid mechanics consist of five groups only, not counting the cavitation criterion, and also excluding problems of heat and mass transfer. (*b*) All those groups are entities, and no mathematical operations are permissible which would change their essential character. This means, *inter alia*, that the groups may not be expanded by a dimensionless parameter, e.g., the term $m\,R_e$, as the area ratio m times the Reynolds Number is ambiguous as well as meaningless.

Therefore, the investigation of the measuring orifice characteristics under pulsating-flow conditions should be carried out on the basis of at least two distinct terms, namely, the Strouhal number and the amplitude ratio, besides other appropriate groups or parameters like the Reynolds number and the area ratio m.

The ratio $\frac{L}{d}$ used by the author corresponds formally to the Strouhal number; however, exception may be taken to the choice of the variables. In the Strouhal number certain variables directly related to the problem may be introduced, e.g., mass rate of flow G, the area A_1 of the pipe line, the density ρ, and as length dimension the distance l from the source of pulsation to the orifice plate, i.e.

$$\frac{u}{fl}=\frac{G}{f\rho A_1 l}.$$

This latter term is also known as the Hodgson criterion, which was accepted internationally in recognition of the outstanding work on pulsating flow by the late John L. Hodgson.* Hodgson states ". . . that the pulsation error due to changes of velocity (as distinct from error caused by pressure waves in the pressure pipes) is the same for the values of the criterion

$$\frac{CFL}{ZG},$$

(which can be deduced by the 'method of dimensions') . . ." where C denotes the capacity of the pipe line between the measuring orifice and the source of pulsation, F the frequency, L the loss of pressure across the orifice, G the mean weight of flow, and Z the specific volume at mean pressure and temperature. The similarity of the Hodgson criterion with the above given expression derived from the Strouhal number is evident, a fact which up to the present seems to have escaped notice. Full credit is due to Hodgson for having established the correct model law for pulsating flow 30 years ago.

Regarding the layout of Dr. Zarek's test plant it would be of interest to know whether the short distance of the pulsating device from the orifice has influenced the velocity distribution in the approach. The velocity profiles should be symmetrical in all planes. Furthermore, the question arises whether any swirling movement of the flow filaments was observed.

Yours faithfully,
F. V. A. ENGEL, Dr.Ing., D.I.C.

8, Seaton-road,
Workington,
Cumberland.
January 15, 1955.

* "The Orifice as a Basis of Flow-Measurement." Selected Eng. Papers. No. 31. The Institution of Civil Engineers, London, 1925.

DESIGN OF APPARATUS

SIR, Having read the article by Dr. J. M. Zarek on "Metering Pulsating Flow" in your issue of January 7, I should like to make the following comments.

The author's statement that the apparatus shown in Fig. 1 enables the required pulsations to be superimposed on the steady flow "while leaving unchanged the quantity of air flowing," is open to criticism. The system of piping shown downstream of the smoothing tanks constitutes a pulsating system which will have a varying resistance to the outflowing air when the pulsator is in operation, due to the influence of the ensuing air wave action. As noted by the author, this has an influence on the static pressure in the smoothing tank. As rotary blowers are very sensitive to variations in the delivery pressure, the mass flow under steady-flow conditions would not be equal to the corresponding mass flow with pulsations present. The author would appear therefore to be determining, not flowmeter pulsation errors, but the combined effect of those errors and of flow variation due to air pulsations in the pipe system. It is suggested, therefore, that the author should have employed some direct means of metering the air flow during the pulsating-flow tests. Providing the smoothing tanks were of sufficient capacity, an orifice meter could have been installed in the ducting joining the tanks. Although this would admittedly not represent an absolute method of determining the true air flow, it would nevertheless be better than having no check at all on flow variation.

In view of the above argument, it is not surprising that the mass flow was in certain cases decreased, and in others increased by the action of the pulsator. It is therefore difficult to understand why the author can offer no explanation of the fact that the so-called "coefficient of discharge," was greater than that for steady flow in the case of certain trials with the pulsator in the downstream position. It might well be that if the author were to extend his experiments to include higher frequencies, or to substitute a different length of piping, a similar result would also be observed with the pulsator in the upstream position.

The results shown in Figs. 3 to 8 should therefore be examined with caution since, in the first place, they refer to the specific system of piping in which the meter was installed and of which the author incidentally gives but few details; secondly, the "correction factors" obtainable from the curves do not enable the true mass flow to be determined. Although the author states that the paper describes only a part of a more general investigation, his report is nevertheless complete in itself and must therefore be assessed as such. While there is not sufficient evidence to support nor to contradict the author's contention that the coefficients of discharge are influenced by pulsating flow, there are strong grounds for disputing his claim that he has determined values of the coefficient of discharge for pulsating flow.

Dr. Zarek's statement that "under pulsating flow a U-tube manometer, either damped or undamped, indicates the mean differential pressure across the orifice" should be carefully qualified. The pressure differential patterns shown in Fig. 2 are of a comparatively simple and symmetrical form, and although the author has omitted to mark a pressure scale on his diagrams, the amplitudes are apparently only of the order of an inch or so of water. Had the author's apparatus been designed to produce less symmetrical waveforms, it is likely that manometer errors would have been evident. In an investigation of this nature it is extremely important that a full description be given of the manometer used, as pressure-pulsation errors may well be introduced by factors such as the length and material of the connecting leads; any changes in the cross-section of these leads; and the type of damping employed both in the connecting tubing and the manometer itself.

No conclusions can be drawn regarding manometer accuracy from the results obtained from the optical indicator described on page 17, as such indicators employing rubber diaphragms are certainly not reliable as far as quantitative results are concerned, and in any case, the mean amplitude registered does not generally correspond to the time-mean of the pressure differential over the cycle. It would be of interest if the author could give a short description of the type of pressure pick-up used with the cathode-ray oscillograph, and indicate how it was connected at the orifice plate. Such small pressure differentials are generally rather difficult to record by this means.

Yours faithfully,
T. J. WILLIAMS, M.Sc., Ph.D.

Engineering Department,
University College of Swansea,
Singleton Park, Swansea.
January 21, 1955.

* * *

SHEAR CENTRES OF COMPOUND GIRDERS

Accuracy of Design Calculations

SIR, I have been considerably interested in the experimental device for determining the position of the shear centre of light alloy sections described by Dr. N. S. Grassam on page 45 of your issue of January 14. Dr. Grassam was good enough to refer to the method of calculating the position of the shear centre of an assymmetrical section which I put forward in your issue of November 26, (page 689, vol. 178), but he appears to doubt whether this gives results which agree with the behaviour of the girder under loads occurring in practice. I should perhaps have mentioned that comprehensive tests, carried out by B.I.S.R.A. on a full-scale 50-ft. span girder under test loads simulating usual crane-wheel loading, have shown that the position of the shear centre, as indicated by the measured deflections, conforms with the position obtained by this method of calculation. It is therefore considered that the calculation referred to can be relied on with confidence.

Yours truly,
J. S. TERRINGTON.

The British Iron and Steel Research Association,
140, Battersea Park-road,
London, S.W.11.
January 21, 1955.

Editor's Note.—It is regretted that, in the article by Dr. Grassam, the illustrations of Figs. 1 and 2 were transposed, so causing a small error in the references in the text.

INSTITUTION OF NAVAL ARCHITECTS

Spring Meeting

Departing from the practice of several recent years, the 1955 spring meeting of the Institution of Naval Architects will be held at the Institution's headquarters, 10 Upper Belgrave-street, London, S.W.1, instead of on board the Wellington, and will take place on Monday, Tuesday and Wednesday, April 4, 5 and 6.

The proceedings will commence with the opening of the Institution's Weir Lecture Hall by the President, Viscount Runciman of Doxford, O.B.E., on April 4, at 5.15 p.m., and the first Amos Ayre Lecture, by Sir Maurice E. Denny, Bt., on "The Man and His Work," will follow. There will be morning, afternoon and evening sessions on April 5, at which the following five papers will be read and discussed: the final Lucy Ashton paper, by Dr. S. Livingston Smith; "Recent Developments in Naval Life-Saving Equipment," by W. J. Holt; "A Hundred Years of Lloyd's Register Ship Rules," by J. M. Murray; "Forty Years of Change at Portsmouth Dockyard," by I. E. King; and "Sea Trials on a 9500 D.W. Motor Cargo Liner," by Professor G. Aertssen. The last-mentioned paper will be presented to the Institution and the Institute of Marine Engineers, jointly, and will be dealt with at the evening session.

The annual general meeting of the Institution will take place on April 6, commencing at 10.15 a.m., and will be followed by a paper entitled "Liners of the Past, Present and Future on Service East of Suez," by Sir William C. Currie, G.B.E. The concluding paper of the meeting, "The Cathodic Protection of Ships Against Sea-Water Corrosion," by L. T. Carter and J. T. Crennell, will be discussed at an afternoon session on the same day, and the Institution's annual dinner will follow at the Connaught Rooms, Great Queen-street, London, W.C.2, at 7 for 7.30 p.m.

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INSTITUTION OF MINING ENGINEERS

Presentation to Sir Andrew Bryan

At the luncheon following the annual general meeting of the Institution of Mining Engineers in London on Thursday, January 27, the President, Major Noel E. Webster, O.B.E., M.C., presented the Institution's Gold Medal to Sir Andrew Bryan, D.Sc., LL.D., F.R.S.E. In making the presentation, the President said that Sir Andrew had begun his career as a boy in the mines picking brasses; he had gone to evening classes, won a bursary to take him to Glasgow University where he graduated with special distinction in mining. Thereafter he became in turn, an Inspector of Mines, Professor of Mining in the University and at R.T.C., Glasgow, general manager and managing director of the Shotts Iron Company, Limited, H.M. Chief Inspector of Mines and now—"for his sins"—a member of the National Coal Board. The medal was awarded, concluded the President, for Sir Andrew's "contribution towards the improvement of the safety, health, education and training of those engaged in our industry, and for his valuable service to our Institution."

During the preceeding meeting, members had heard Mr. E. H. Browne deliver his paper "The Coalfields of Great Britain and their Future Development," reported elsewhere in this issue. Members had also heard of the success of the campaign, well supported by Major Webster's presidential address of last year, to obtain new members, particularly among students and associates of the constituent institutes.

NEW EXHIBITS AT SCIENCE MUSEUM

HISTORIC FIRE ENGINES AND MODEL STEELWORKS

Steel making is one of the most important industries of Great Britain to-day. More than half a million people are employed in steelworks, and the yearly output has risen in the last seven years from 12½ to 18¼ million tons. To show how steel is made, and to give some idea of the complexity and size of a steelworks, the British Iron and Steel Federation, Tothill-street, London, S.W.1, are exhibiting a model plant at the Science Museum, South Kensington. The model, which is shown in the illustration below, was made for the B.I.S.F. by the City Display Organisation, 281 Goswell-road, E.C.1; it stands on a floor area of 60 ft. by 24 ft., and portrays a steelworks covering a site of over a quarter of a square mile and having a weekly capacity of 20,000 tons.

The raw materials are shown arriving by rail and ship. The coal for coking comes by rail and is made into coke in a battery of coke ovens. Close to the coke ovens is the by-products plant; here coke-oven gas is passed through various processes, during which benzol, tar, and sulphate of ammonia are recovered, and the clean gas is stored in a gas-holder until it is needed for use in other parts of the works. A large proportion of the iron used in the British steel industry comes from our own ironstone fields, but much high-grade ore comes from abroad; in the model a 10,000-ton ore ship has arrived and is unloading its cargo into the ore stockyard. The ore and coke are fed into the top of the two blast-furnaces by skip hoists. When the iron is smelted from the ore it is tapped from the bottom of the furnaces and taken straight to the steel furnaces in ladles or made into pig-iron in a moving-belt pig-casting machine. In the model the working parts are the transporter crane for moving ore into and out of the stock-yard, the skip hoists and the hot-metal cars.

In the centre of the model is the steel-melting shop, which consists of six large oil-fired furnaces. The main raw materials in a real works are molten iron, scrap, and limestone. On one side the raw materials are charged through the furnace doors, and on the other, molten steel is tapped into huge ladles which are then poured into ingot moulds, where the steel solidifies; the moulds are prepared in a building which is shown close by the steel-melting shop. When the ingots are cool they are taken by rail to the rolling mills; first they are re-heated to an even temperature in soaking pits, and taken from these to the cogging mill. The cogging mill performs the first stage in rolling, and is followed by further stages in the plate mill. The steelworks in the model shows the manufacture of plate, and the dispatch bays of the plate mill are shown in the left foreground of the illustration.

A diagram on the back wall of the model, seen on the right of the illustration, shows the general layout of the steelworks. For the layman, or the engineer who has had little to do with steel production, the organisation of a steelworks needs more explanation than is given by the model itself or the diagram. This explanation can be obtained from a B.I.S.F. guide, who is always in attendance; the combination of visual and verbal instruction gives a very clear picture of the way steel is produced.

The model is to be exhibited until the end of 1955. Parties can be taken round, but in this case it is advisable to arrange it beforehand with the Science Museum or the British Iron and Steel Federation, so that parties will not clash.

FIRE-FIGHTING APPLIANCES

The Science Museum's collection of fire-fighting appliances, which has been in store since the outbreak of the war, has now been reopened to the public. Since 1939 a full-sized steam fire engine and four model engines have been added to the collection. These include an original model manual engine dating from 1680, which is now the first of a series of exhibits illustrating the development of the fire engine from early equipment up to the modern appliance. Auxiliary apparatus such as alarms, escapes and extinguishers are also on view.

The Science Museum is open on weekdays from 10 a.m. until. 6 p.m. and on Sundays from 2.30 until 6 p.m. Admission is free.

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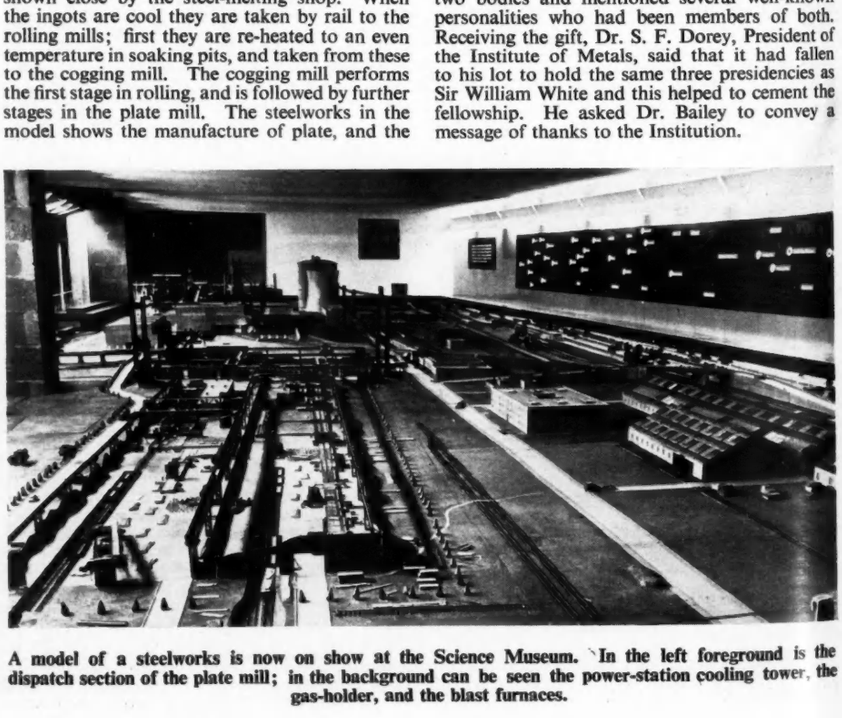
PRESENTATION TO THE INSTITUTE OF METALS

On January 25, the Institution of Mechanical Engineers presented, on permanent loan, a portrait of Sir William H. White to the Institute of Metals of which Sir William was Founder-President. Dr. R. W. Bailey, F.R.S., President of the Institution of Mechanical Engineers, before he unveiled the portrait, recalled the association that had always existed between the two bodies and mentioned several well-known personalities who had been members of both. Receiving the gift, Dr. S. F. Dorey, President of the Institute of Metals, said that it had fallen to his lot to hold the same three presidencies as Sir William White and this helped to cement the fellowship. He asked Dr. Bailey to convey a message of thanks to the Institution.



A model of a steelworks is now on show at the Science Museum. In the left foreground is the dispatch section of the plate mill; in the background can be seen the power-station cooling tower, the gas-holder, and the blast furnaces.

PERSONAL

THE ENGLISH STEEL CORPORATION LTD., Sheffield, 9, have announced appointments to the boards of five newly-formed subsidiary companies, namely, ENGLISH STEEL FORGE AND ENGINEERING CORPORATION, LTD., ENGLISH STEEL ROLLING MILLS CORPORATION, LTD., ENGLISH STEEL CASTINGS CORPORATION, LTD., ENGLISH STEEL SPRING CORPORATION LTD., and ENGLISH STEEL TOOL CORPORATION LTD. MR. FRANK PICKWORTH is the chairman and MR. F. S. BEALE a director of all five companies. MR. W. D. PUGH is the managing director of the "Forge and Engineering Corporation" and the other directors are DR. H. H. BURTON, DR. C. J. DADSWELL, MR. G. GILFILLAN and MR. W. E. A. REDFEARN. MR. R. G. H. TAYLOR is the managing director and MR. H. SCHOLEY a director and the general manager, of the "Rolling Mills Corporation" and the other director is MR. W. D. PUGH. DR. C. J. DADSWELL is the managing director of the "Castings Corporation" and the other directors are MR. W. C. MUIRHEAD and MR. W. D. PUGH. DR. C. J. DADSWELL is also the managing director of the "Spring Corporation" and the other directors are MR. W. C. MUIRHEAD and MR. W. D. PUGH. MR. R. G. H. TAYLOR is the deputy chairman, and MAJOR-GENERAL E. P. READMAN the managing director, of the English Steel Tool Corporation, Ltd.

CAPTAIN H. LEIGHTON DAVIES, C.B.E., J.P., has been appointed chairman of the Welsh Board for Industry, as from February 1, in succession to SIR PERCY THOMAS, O.B.E., J.P., D.L., who has been chairman of the Board since its inception in 1942.

VISCOUNT COBHAM has been elected a director of Associated Electrical Industries Ltd.

SIR JAMES REID YOUNG, C.A., F.C.I.S., has joined the board of International Combustion (Holdings) Ltd.

SIR WILLIAM PATERSON, founder of the Paterson Engineering Co. Ltd., Windsor House, Kingsway, London, W.C.2, has retired from the positions of chairman and managing director after 53 years of service. MR. J. V. SHEFFIELD has been elected chairman, MR. O. C. KERRISON, managing director, and MR. S. W. BURRELLS, secretary.

SIR RONALD C. STEWART, Bt., deputy chairman of the London Brick Co. Ltd., has joined the board of directors of Transformers (Watford) Ltd., Sandown-road, Watford, Hertfordshire.

MR. C. H. NICHOLSON, M.I.E.E., M.I.Mech.E., mechanical and electrical engineer of the British Transport Commission's Humber ports, retired from that position on December 31, 1954, but is remaining in the service of the British Transport Docks Division in an advisory capacity as mechanical and electrical engineer (general duties).

MR. G. H. DOWTY, F.R.Ae.S., chairman and joint managing director of Dowty Equipment Ltd., Cheltenham, Gloucestershire, has been made an honorary freeman of the Borough of Cheltenham.

The second term of office of the Central Transport Consultative Committee for Great Britain having expired, the Minister of Transport and Civil Aviation has appointed LORD COLERAINE, P.C., to be chairman of the new committee. The serving members of the committee have all been re-appointed to continue as members until December 31, 1957. Four new members have been appointed, namely, MR. S. C. ROWELL, of Manchester, MR. I. HOOPER, chairman, General Steam Navigation Co., Ltd., London, MAJOR W. H. POWELL, D.S.O., J.P., member, Portsmouth City Council, and MR. A. MACLEAN, Provost of Paisley. The office of the Committee is at 22 Palace Chambers, Bridge-street, London, S.W.1.

COLONEL M. D. METHVEN, manager of North-Eastern Trading Estates Ltd., for the past 19 years, has retired.

CAPTAIN (E) SIR JOHN R. COOTE, Bt., C.B.E., D.S.C., R.N., has been promoted to be rear-admiral (E) as from February 28. He will relieve Rear-Admiral (E) SIR ALEX. D. MCGLASHAN, K.B.E., C.B., D.S.O., as deputy Director of Naval Ordnance (material) and chief ordnance engineer officer.

MR. A. I. ANDERSON has been nominated as President of the Chamber of Shipping of the United Kingdom, 3-6, Bury-court, St. Mary Axe, London, E.C.3, for the current year. MR. K. R. PELLY, M.C., M.Inst.T., has been nominated vice-president.

Following the death in September, 1954, of MR. H. G. YATES, senior designer of the Parsons and Marine Engineering Turbine Research and Development Association, Pametrada Research Station, Wallsend, Northumberland, MR. B. J. TERRELL, M.B.E., B.Sc.(Eng.), has been appointed senior designer, MR. R. F. DARLING, B.Sc., senior research engineer and MR. M. H. PETTY, M.A., deputy senior research engineer.

MR. J. I. CAMPBELL, M.I.C.E., chief civil engineer, Eastern Region, British Railways, retired on January 26.

MR. A. J. BEANLAND, general manager, Trafford Park Works, Lancashire Dynamo & Crypto Ltd., and MR. C. F. JACKSON, general manager of the firm's Willesden Works, have been elected to the board of directors of the company.

MR. G. W. HALL, A.F.R.Ae.S., has been appointed an assistant managing director of the Fairey Aviation Co., Ltd., Hayes, Middlesex, in addition to MR. L. MASSEY HILTON, D.F.C., A.F.C., A.F.R.Ae.S. Mr. Hilton will be concerned primarily with the Group organisation and policy as a whole and Mr. Hall will be in general charge of the executive and administrative organisation of the company.

MR. T. H. ARNOLD, F.I.M., has been elected President of the Sheffield Metallurgical Association, in succession to MR. F. H. SANITER, B.Eng.

MR. GEORGE TALBOT has joined the staff of the Wellman Smith Owen Engineering Corporation Ltd., Parnell House, Wilton-road, London, S.W.1, as general manager of the furnace-building and contracting division of the firm.

MR. W. LEWIS SMITH has been appointed chairman of the Cable Makers' Association, MR. R. A. BEBB chairman of the Mains Cable Manufacturers' Association, MR. H. E. HELWIG, chairman of the Mains Cable Manufacturers' Association (Super Tension) for the second year, MR. H. LOCKETT, chairman of the Overseas Rubber Cable Manufacturers' Association, and MR. H. H. TOWNSEND, chairman of the Rubber and Thermoplastic Cable Manufacturers' Association.

MR. HARRY FOSTER-SMITH, senior assistant engineer, British Electricity Authority, has just gone to Venezuela, to carry out a year's assignment for the United Nations Technical Assistance Administration. The latter was asked by the Government of Venezuela for a production engineer having extensive experience in the management of electrical plant.

MR. H. L. SATCHELL, M.B.E., a director of the British Thomson-Houston Co. Ltd., Rugby, has been appointed deputy director of manufacture of the firm. On March 1, Mr. Satchell will relinquish the managership of the Rugby Works in favour of MR. H. E. COX, M.I.E.E., who has been manager of the firm's Willesden Works since 1946.

MR. S. J. PRESTON, M.A. (Cantab.), A.M.I.E.E., a chief executive officer of the patent department of Electrical and Musical Industries Ltd., has been elected chairman of the Radio Communication and Electronic Engineering Association in succession to MR. C. G. WHITE.

MR. E. N. B. HAMMOND has been made engineer-in-charge of the new Norwich television station of the British Broadcasting Corporation. He will also continue to be responsible for the Home Service transmitting station at Postwick, near Norwich.

MR. A. L. MARKHAM has been appointed works manager of the new Dunstable factory of Commer Cars Ltd., Luton. The appointment of MR. P. D. RATCLIFFE, M.A., as Commer-Karrier sales promotion manager has also been confirmed.

MR. R. H. SEMPLE, regional manager in Scotland for British Insulated Callender's Cables Ltd., has accepted an appointment with British Insulated Callender's Cables (Australia) Pty. Ltd. He is leaving for Sydney in March.

MR. KENNETH TEALE, A.M.I.P.E., has been made chief efficiency engineer to Short Brothers and Harland Ltd.

MR. H. DE C. FALLE, O.B.E., A.M.I.E.E., has retired from the position of general sales manager, Aberdare Cables Ltd., after completing 50 years in the electrical industry. He will remain on the boards of Aberdare Cables (Holdings) Ltd., Aberdare Cables Ltd., and South Wales Switchgear Ltd. MR. W. R. HALL, export manager, will continue to operate from the London office, and MR. C. A. HUTCHINSON, M.I.E.E., will be responsible for home sales with headquarters in London.

MR. G. G. BALDWIN has been appointed agricultural-machinery adviser of the tractor division of the David Brown Corporation (Sales) Ltd. MR. A. J. WARDE DIXON has been appointed export sales manager of the division.

MR. J. A. JOHNSTON, A.C.A., special director and secretary of Francis Morton & Co., Ltd., Hamilton Ironworks, Garston, Liverpool, 19, has been elected a director of the company, with effect from January 19. He retains the secretaryship.

MR. R. A. SEFTON JENKINS, B.Sc., A.C.G.I., A.M.I.C.E., A.M.I.Struct.E., consulting engineer, has moved his office to 66, Victoria-street, London, S.W.1. (Telephone (unchanged) TATe Gallery 9605).

MR. DUDLEY THOMAS has joined the sales staff of C.A.V. Ltd., Acton, London, W.3.

In consequence of the death on January 4 of MR. D. GOLDBERG, sales manager to Keith Blackman Ltd., Mill Mead-road, Tottenham, London, N.17, for over 38 years, MR. C. J. ATKINS has been made sales manager, MR. A. H. WOODLEY, assistant sales manager, MR. F. W. GOODGE, contracts manager, and MR. D. HUMPHREY, assistant to the chief engineer. These appointments became effective on February 1.

DR. G. W. RIGBY has been appointed European technical representative of E. I. du Pont de Nemours & Co. He will maintain his headquarters at the firm's main offices in Wilmington, Delaware, U.S.A., but will spend a substantial part of his time travelling in Europe.

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COMMERCIAL

MATTHEWS AND YATES LTD., Cyclone Works, Swinton, Manchester, have transferred their London office to larger premises at 135, Rye-lane, Peckham, S.E.15. (Telephone: NEW Cross 6571.)

THE MORSE CHAIN CO. LTD., Letchworth, Hertfordshire, have changed their name to BORG-WARNER LTD.

VARLEY PUMPS AND ENGINEERING LTD., the British subsidiary company of FOOD MACHINERY AND CHEMICAL CORPORATION, of California, U.S.A., have acquired the whole of the Ferry-lane, Brentford, Middlesex, property, part of which they have occupied for the past two years. This new acquisition will enable the firm to carry out an expansion programme.

The name of COMPRESSION IGNITION LTD., a subsidiary company of SHEEPBRIDGE ENGINEERING LTD., Chesterfield, has now been changed to TWIFLEX COUPLINGS LTD.

MACKAY INDUSTRIAL EQUIPMENT LTD., Faggs-road, Feltham, Middlesex, have acquired from ALAN MUNTZ & CO. LTD., Heston, Middlesex, an exclusive licence covering the manufacture and sale of PESCARA-MUNTZ free-piston air compressors in Great Britain, Eire, the British Dominions, Colonies, Portectorates and Mandated Territories (including India), and Egypt.

Following inspection by the Aeronautical Inspection Directorate of their new factory, CREATORS LTD., manufacturers of thermo-plastics, now at Plansel Works, Sheerwater, Woking, Surrey, have been granted A.I.D. approval. This follows the temporary suspension of the A.I.D. approval, on the occasion of the transfer of premises, previously granted to the company.

THE JOHN THOMPSON GROUP OF COMPANIES removed from their temporary offices at "Ravenswood," Westfield-lane, Ryton-on-Tyne, to permanent office accommodation at "A" Floor, Milburn House, Newcastle-upon-Tyne, on February 1. (Telephone: Newcastle 29720.)

SOAG MACHINE TOOLS, LTD., have acquired some 22,000 sq. ft. of additional showroom and storage space in Battersea. These premises are in addition to the firm's offices and showrooms at Juxon-street, Lambeth, S.E.11.

THE ENGLISH ELECTRIC CO. LTD. have taken over premises from the Ministry of Supply, at Whetstone, Leicester. These were previously occupied by the National Gas Turbine Establishment, and the work to be carried out henceforth will consist largely of research and development associated with power-station engineering. Industrial gas-turbine development and work on steam turbines, water turbines and Diesel engines will be also conducted at Whetstone.

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CONTRACTS

Oil-Firing Boiler Equipment. An order for the conversion to oil-firing equipment of the boiler plant at the London County Council County Hall has been placed with LAIDLAW DREW & CO. LTD., Leith, Edinburgh.

Interceptor Fighting Aeroplanes. The Ministry of Supply have placed an order for D.H.110 all-weather interceptor fighters for service in the Royal Navy. The aircraft are supplied by the DE HAVILLAND AIRCRAFT CO. LTD., Hatfield, Hertfordshire.

Pipeline. STEWARTS AND LLOYDS LTD. have received an order for the supply of 490 miles of line pipe from the main contractors, BROWN-RAYMOND-WALSH, for the American bases in Spain. The value of the contract is approximately £2 million.

Motorship. The Chine Shipping Co. Ltd., have placed an order with HENRY ROBB LTD., Leith, for a single-screw motorship of 5,500 tons dead-

weight carrying capacity. The new ship will be similar to the M.S. Longfellow, built for the Rodney Steamship Co. Ltd. The main and auxiliary machinery will be supplied by SULZER BROS. LTD., Winterthur, Switzerland.

Rock-Fill Dam. The North of Scotland Hydro-Electric Board have placed a contract for the construction of a dam at Loch Fannich, Ross-shire, with JOHN LAING & SON, LTD., civil-engineering contractors, London. The dam will be a rock-fill structure, 2,400 ft. long and 30 ft. high, with a central section of mass-concrete gravity dam. It will raise the water level of the loch by about 20 ft. and will increase the water storage for the power stations at Grudie Bridge, Luichart and Torr Achilty and raise the annual output of the Fannich Scheme by 3 million units, to a total of 82 million units. The civil-engineering consultants for the scheme are SIR ALEXANDER GIBB AND PARTNERS.

Bolster Wagons. The British Transport Commission have placed an order for 600 thirty-ton bogie bolster wagons with the METROPOLITAN-CAMMELL CARRIAGE AND WAGON CO. LTD., Saltley, Birmingham. They are for use on British Railways.

Turbo-Generator Sets. The Johannesburg Municipality have placed an order with the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, to supply, for the Kelvin power station, three 30 MW turbo-generator sets, complete with feed-heating and evaporating plant, bringing the total number of sets on order or under construction for this station to six. The turbines will operate under steam conditions of 600 lb. per square inch gauge at the turbine stop valve and a temperature of 850 deg. F. The machines are of two-casing design with 22 stages of high pressure and six stages double flow of low pressure. The 37,500-kVA alternators, which are air-cooled, generate at 11 kV and have direct-coupled exciters. Each set is provided with a four-stage feed-heating plant giving a final feed temperature of 356 deg. F., at full load, designed and manufactured by VICKERS-ARMSTRONGS LTD. The consultants for the Municipality are MESSRS. MERZ & MCLELLAN.

Aluminium Conductor. The ALUMINIUM WIRE AND CABLE CO. LTD., Port Tennant, Swansea, have been awarded a contract for over 250 miles of large-sized steel-cored aluminium conductor, to an approximate value of £114,000, for the new 220-kV electrical-grid system in Tasmania.

Steel Water-Main Pipes. A contract for the manufacture and supply of 3,000 tons of 27-in. and 24-in. diameter lapwelded steel water-main pipes for the Birkenhead Corporation has been awarded to HORSELEY BRIDGE & THOMAS PIGGOTT LTD., Tipton, Staffordshire. These large-diameter pipes are to be used for the Corporation's Alwen-Aqueduct duplication and the River Dee scheme.

Distribution Transformers. MESSRS. TRANSFORMERS (WATFORD) LTD., Sandown-road, Watford, Hertfordshire, who recently announced that they had introduced, for the first time in this country, the manufacture of class-H air-cooled silicone-impregnated distribution transformers, now announce that they have been successful in securing a large contract, in Italy, for similar class-H transformers.

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OBITUARY

We regret to record the deaths of:

MR. CHARLES BROADBENT PERKINS, M.I.Mech.E., at Weymouth, on December 14, 1954, at the age of 79. Mr. Perkins, who had been in semi-retirement for the past eight years, was for upwards of 40 years the representative in this country of the steelworks of George Fischer Ltd., Schaffhouse, Switzerland. During the years 1940 to 1950 he was representative of the malleable-castings division of the Britannia Iron and Steel Works Ltd., Britannia Iron Works, Bedford.

MR. GEORGE GALLOWAY, on January 14, at the age of 80. Mr. Galloway was founder and a director of Geo. Galloway & Co. Ltd., engineers, 43 Middlesex-street, Glasgow, C.5.

MR. RICHARD BOWNESS HODGSON, at Sheffield on January 27, in his 89th year. Mr. Hodgson was a former managing director of Whessoe Ltd., Darlington, and retired in 1935. In his younger days he was works manager of the Workington Bridge & Boiler Co. and, in 1907, he joined the staff of Ashmore, Benson, Pease & Co. Ltd., Stockton, as works manager. Mr. Hodgson subsequently became general manager and a director. In 1924, on the death of Mr. A. Coates, Mr. Hodgson was appointed managing director of Whessoe Ltd., a position he occupied for 11 years.

ELECTRICITY SUPPLY IN CANADA

A RECORD YEAR IN WATER POWER DEVELOPMENT

According to a survey prepared by the Water Resources Division of the Canadian Department of Northern Affairs and National Resources, no less than 1,758,450 h.p. of new hydro-electric plant was brought into operation in the Dominion during 1954. This established a record, the previous highest year being 1952, when 1,066,250 h.p. was connected. The total installed capacity of water power plant at the end of the year was 16,684,200 h.p., but this represents a development of less than 26 per cent. of the total resources of the country. New plant and extensions, which are scheduled for operation in 1955, total about 1,000,000 h.p., while those envisaged for later years amount to 2,500,000 h.p. In addition, it is probable that development on several sites of high capacity will be undertaken in the not remote future.

A number of new thermal stations and extensions to existing plant were also completed. New main transmission lines were connected or under construction in many parts of the country and included submarine cables across the Lower St. Lawrence River and the Strait of Georgia.

EXTENSIONS AT NIAGARA

Analysing the progress made in the different provinces it is pointed out that no less than 735,000 h.p. of the total increase was installed in the Sir Adam Beck-Niagara generating station No. 2 in Ontario. This consists of seven 105,000-h.p. units and five more are to be added making a total installed capacity of 1,260,000 h.p. It is expected that the pumped-storage reservoir which forms part of the scheme will be completed in 1955, and the six reversible pump-turbine units, each of which will have an output of 40,000 h.p., should be ready for operation a year later.

Under the terms of the Niagara Diversion Treaty remedial works were planned to control the water level of the river and to enhance the beauty of the falls. These works include a 1,550-ft. control dam on the Canadian bank, the construction of which was commenced in December, 1953. Erection is being carried out in six stages, the cofferdamming in two of which has been completed. The final structure will comprise 13 individually-operated bascule-type control gates, which will be mounted on concrete piers, and it is expected that two of these will be completed in April next.

Agreement was reached between the Hydro-Electric Power Commission of Ontario and the New York State Power Authority for the international development of the St. Lawrence River; the necessary constructional works, which were begun in August, 1954, include a main dam and power house between Barnhart Island and the Canadian shore and two control dams, one at the foot of the Long Sault Rapids between Barnhart Island, the United States shore and the other across the main channel below Galop Rapids near the village of Iroquois in Ontario. The generating plant will consist of 16 75,000-h.p. sets, of which the first is expected to be in service in 1958.

DEVELOPMENTS IN BRITISH COLUMBIA

Another large addition to the power resources of the Dominion was represented by the Kemano-Kitimat development in British Columbia of the Aluminium Company of Canada. This scheme, which has already been described in ENGINEERING,* has a present installed capacity of 450,000 h.p. in three 150,000-h.p. units. These operate under a head of 2,485 ft. and power from them is transmitted a distance of 50 miles at 287 kV. A fourth 150,000-h.p. set is being installed.

In the same province the Consolidated Mining and Smelting Company of Canada completed the first stage of their Waneta development on the Pend d'Oreille river. This consists of two 120,000-h.p. units operating under a 210-ft. head. The British Columbia Electric Company installed a 62,000-h.p. set in their Bridge River plant, bringing the total capacity up to 248,000 h.p., and are raising the hight of the La Joie dam to give an eventual storage of 570,000 acre-ft. The same company are engaged in several other developments, including the construction of a 345-kV line between Bridge River and Vancouver, a distance of 100 miles. Three single-core submarine cables are being laid across the Strait of Georgia. They will be 15 miles long and will be laid at a maximum depth of 640 ft. They will have a power-carrying capacity of 120 MVA at 132 kV and will contain nitrogen at a pressure of 300 lb. per square inch.

THE BERSIMIS SCHEME

Only 54,700 h.p. of new capacity was commissioned in Quebec. On the other hand, considerable constructional work was in progress, the most important of which was in connection with the 1,200,000-h.p. scheme of the Quebec Hydro-Electric Commission on the Bersimis River. This includes a main dam 200-ft. high at the outlet of Lac Casse, a tunnel 7½ miles long and 31½ ft. in diameter and an underground power house. In addition to a good deal of clearing and road-building work, excavation for the tunnel and power house was begun during the year. The output of this station will initially be transmitted to the Gaspe peninsula, a distance of 31½ miles through four 69-kV submarine cables, which have been laid across the St. Lawrence.

The Shawinigan Water and Power Company carried out preliminary work for the installation of a total of 158,500 h.p. in three stations, and it is expected that this additional capacity will be in use this year. The Gatineau Power Company is installing a 47,000-h.p. 60-cycle set at Paugan Falls. This marks a preliminary step to a change-over from 25 cycles on the system of this concern. The Canadian International Paper Company is installing two 20-MW electric boilers.

PROGRESS IN YUKON

In southern Yukon and northern British Columbia, North Western Power Industries, Limited, investigated a scheme with an estimated ultimate capacity of 4,300,000 h.p. This involves the conversion of the lakes in the headwaters of the Yukon River into a storage reservoir by building a series of dams and diverting the flow of the river and other water courses into the valleys south of Atlin. A 28,000-h.p. station is to be erected on the Sloko River for constructional purposes and a 10-mile tunnel will then be driven from the Sloko Lake to the Nakonake Valley. This will enable 880,000 h.p. to be operated initially at a head of 1,100 ft., this figure being later increased to 2,800,000 h.p. Subsequently, a tunnel will be driven to the Taku River.

Additions of a less spectacular character both to water power and steam plant and the transmission systems were also made in Alberta, Saskatchewan, Manitoba, New Brunswick, Nova Scotia and Newfoundland, and these are referred to in detail in the report.

* See vol. 177 page 430 (1954)

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ESSAY COMPETITION

The subject this year for the John S. Owens essay competition is "The Problem of Engine Exhaust Fumes from Road Vehicles." The winning essay will be awarded a prize of £50. Full particulars may be obtained from the Secretary, Royal Sanitary Institute, 90 Buckingham Palace-road, London, S.W.1.

BOOK REVIEWS

Adhesive Bonding of Metals. By GEORGE EPSTEIN. *Reinhold Publishing Corporation, 330 West 42nd-street, New York 36, N.Y., U.S.A.;* and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (24*s.*)

One of the adhesives dealt with in this book, Redux, was the subject of comment during the Comet Inquiry and the unfortunate expression "stuck together with glue" was used. To the uninitiated general public, this will suggest carpenter's glue. If any structure in which some parts are connected by an adhesive is to be described in this way, then it would be permissible to say that Westminster Abbey is "stuck together with glue." Redux, a British product, is not the main subject of this book which is chiefly concerned with metal adhesives developed in America, but some information about tests with Redux is given; in a study of fatigue strength, failure with adhesive-bonded stiffeners in aircraft panels did not occur until after 4,500,000 cycles of stress; with rivets failure took place after 300,000 cycles. It is added that aircraft with Redux-bonded components are "to-day flying in all parts of the world, under all possible climatic conditions." Full credit for the development of this material is given to Mr. N. A. de Bruyne of Aero Research, Limited, Duxford, Cambridge.

The applications of metal-bonding adhesives are in no way limited to aircraft, and the author of this book refers to their use in the construction of freight wagons, portable buildings and metal windows, and for bonding silicone rubbers and brake linings to metals. This matter is led up to by a consideration of the practical manufacturing advantages of such adhesives in reducing production costs and increasing output. The greater part of the book is devoted to a description of the properties and chemical nature of the various metal-bonding adhesives which have been developed. They are classed under three types—thermosetting resins, thermoplastic resins and elastomeric materials. It is the former which is of importance in structural work; thermoplastic resins have been found particularly valuable for bonding non-metals to metals. This applies also to elastomeric materials which are also used as modifying agents in thermosetting resins. It is clear from the large number of trade names quoted in this book that a very considerable variety of metal adhesives has been developed. The range of their employment is likely to extend and a study of this book may be recommended to those concerned with a wide class of metal assembly.

Lightning Protection for Electric Systems. By EDWARD BECK. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (6·50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (52*s.*)

It is stated at the outset of this book that there are on an average 44,000 lightning storms a day and about 100 lightning strokes per second. Fortunately, they are not all in the same place, although some localities are unduly favoured. In the United States, Florida and New Mexico have more than their fair share. The reason for the attraction of certain localities for lightning strokes is not precisely known, although the nature of the land, or water, surface clearly has an influence; in any given latitude, thunderstorms are more frequent over the land than over the sea, and in mountainous country convection currents assist the upward deflection of warm, damp air. Mr. Beck, in this book, suggests that the geological formation of the earth's surface has an influence, the boundary between two different geological areas promoting stroke production. The specific inductive capacity of the soil is thought to have an influence on the nature of the stroke, high resistivity tending to decrease the magnitude and lengthen duration.

The discussion on lightning formation constitutes an interesting but preliminary feature of this book, the essential subject of which is protective measures. In connection with the almost universally applied terminal rod, connected to an earthed conductor, for the protection of high buildings, it is stated that the zone of protection lies within a cone making an angle of 30 deg. with the vertical; it is added, however, "as a general rule of thumb," that the cone of protection has a diameter equal to the height of the shielding mast. These are not quite the same thing, but this is clearly a matter on which precise statement is not possible. The British Standard Code of Practice states that the protected zone lies inside a cone having a base radius equal to its height. Grounding, a vital element in any lightning protection system, is dealt with by the author in considerable detail and the importance of connecting metal structures to earth is stressed. He states that tall steel-reinforced buildings, such as the Empire State Building, are frequently struck without the occupants being aware of it.

The main body of the book, as its title indicates, is concerned with the protection of electrical plant and transmission lines, the selection and application of arresters for high- and low-voltage systems being discussed in detail with appropriate diagrams of connections, characteristic curves and records of performance. The protective arrangements for, say, low-voltage overhead distribution lines will naturally differ greatly from those necessary for important rotating machines; these latter may, for instance, embody capacitors. Nonetheless, the actual arresters with which Mr. Beck deals are restricted to two main types. Earlier forms, such as water-tube and electrolytic arresters, are considered to be only of historic interest.

The two types are explusion arresters, and valve arresters. The first of these is simple and inexpensive. Essentially it consists of a fibre tube carried between two metal electrodes serving as terminals; the arrester is usually mounted in series with a spark gap. The lower electrode is formed with a vent and when a discharge takes place through the tube, gas is evolved and as it is vented interrupts the current like a fuse. The arrester will operate repeatedly without attention. Although the formation of gas will gradually enlarge the bore of the fibre tubes, they are found to have a long life in service. Arresters of this type are used mainly for transmission lines.

Valve arresters are of various types, but most embody a valve element consisting of small crystals of silicon carbide, either with a binder or held together by compression. In one make, pellets of an oxide of lead are used. The valves, which are mounted in series with a spark gap, have a high apparent resistance at low voltage but a low apparent resistance when a high current flows through them. A typical cathode-ray oscillogram shows that the valve has a voltage-limiting characteristic. It is normally an insulator but becomes a conductor of low impedence limiting lightning voltages. The valves re-establish themselves as insulators after the surge has passed and will operate repeatedly. In addition to information about the selection and installation of arresters for the protection of the various types of equipment, such as overhead lines, transformer banks and station machinery, this instructive book deals with the testing of arresters and gives statistical data about the frequency with which they have been found to discharge in practice.

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INDEX TO "ENGINEERING"

Volume 177 now ready

The Index to Volume 177 of ENGINEERING (January-June, 1954) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 35 and 36, Bedford-street, London, W.C.2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list. Those already on the mailing list need not re-apply.

BOOKS RECEIVED

Some of the books noticed in the Books Received column are selected for extended review in later issues of ENGINEERING.

Drop, Press and Machine Forging. By J. C. SHARMAN. *The Machinery Publishing Company, Limited, National House, West-street, Brighton,* 1. (17*s.* 6*d.*)

This book covers all aspects of modern hot forging by drop hammer, press and forging machines. Subjects covered include forging die design and making, forging machinery and its maintenance, types of furnace and methods of heating the billet, inspection, layout of plant, and estimating.

Report of Committee on Vaporizing Liquid Extinguishing Agents. Fire Research Technical Paper No. 2. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.*).

The Committee was set up by the Fire Research Board in 1952 to review the characteristics desirable in vaporising liquids for use in putting out fires, and to advise on tests to assess the suitability of promising alternatives to compounds at present in use. In this report the agents are assessed by their efficiency as fire fighters, their toxicity and the toxicity of their decomposition products, their physical properties, their effect on materials with which they come in contact, and their cost. Among the newer extinguishing agents, the fluorobromo hydrocarbons show advantages which could justify their use despite their higher cost, and the Committee recommends that their development should be continued.

Hydraulic Operation and Control of Machines. By IAN MCNEIL. *Thames and Hudson, Limited, 244 High Holborn, London, W.C.*1. (35*s.*)

This book presents the principles and applications of hydraulic equipment to machinery. Such subjects as hydraulic packing, fluid media and the care and maintenance of hydraulic plant have been fully treated. Information on the relative merits and operating costs of the various types of hydraulic drive are also included. Although older established methods of hydraulic drive are covered, stress is laid on present-day developments and future trends.

The Design of Cylindrical Shell Roofs. By J. E. GIBSON and D. W. COOPER. *E. and F. N. Spon, Limited, 15 Bedford-street, London, W.C.2.* (35*s.*)

The empirical data and mathematical tools for solving the problems involved in the design and construction of concrete shell roofs are dealt with in this book. After a general treatment of cylindrical shells, the text follows through the complete problems raised by specific types, with and without edge beams. The necessary mathematics is fully set out, and there is a section on the use of matrices.

The Practical Engineer Pocket Book. Edited by N. P. W. MOORE. Sixty-fifth edition. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (12*s.* 6*d.*)

In this edition a new section has been added on industrial hygiene. The section on bearings and mechanical transmission has been largely rewritten, and the locomotive section has been revised and extended. In the section dealing with unified screw threads the latest British Standard Specification on this subject has been taken into account. A selected list of trade and research associations has been added for reference.

Industrial Water Resources of Canada: Fraser River Drainage Basin, 1950-51. By J. F. J. THOMAS. Water Survey Report No. 6. *Department of Mines and Technical Surveys, Mines Branch, Industrial Minerals Division, Ottawa, Canada.* (75 cents.)

This report is the sixth in a series on the chemical quality of surface and municipal water supplies available for industrial and domestic use in Canada. Part I tabulates the analytical results of daily, monthly and spot sampling of surface waters in the basin. Part II reports similar analytical data obtained on municipal waters within the basin, and also includes information on the operation of most of the organised water systems.

Report of the 39th National Conference on Weights and Measures, 1954. U.S. National Bureau of Standards, Miscellaneous Publication 212. *The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.* (50 cents).

The Conference is reported in chronological order of papers presented, and a report of the discussions is included. Details are also given of Officers and Committees, Committee Meetings, and those attending the Conference.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Fractional h.p. Electric Motors. THE BRITISH THOMSON-HOUSTON CO. LTD., Rugby. Choice of fractional h.p. motors, installation, motor connections; care and maintenance, ordering of replacements and spares; technical data, with performance curves. Pocket book, with very comprehensive diagrams and illustrations; copy will be sent to any machinery manufacturer, electrical contractor, or maintenance engineer, applying on business letterhead to Manager, Technical Publications Dept., British Thomson-Houston Co. Ltd. Rugby.

Building Insulation Board. BOWATER BUILDING BOARDS LTD., Bowater House, Stratton-street, London, W.1. Insulation board for lining new and existing buildings; Lloyd metal fixing systems for quick installation. Booklet "The Heat Barrier" quotes and illustrates examples of work done by company in well-known factories; discussion on thermal insulation, data and typical calculations; examples of fixing systems and applications.

Electrical Actuators. THE PLESSEY CO. LTD., Ilford, Essex. Basic principles and some applications of electrical actuators, for use in aeronautical and other spheres. Illustrated booklet with comprehensive descriptions of various types of actuator, including dimensions, circuit diagrams and performance graphs.

Paper-Making Machinery. MILLSPAUGH LTD., Alsing-road, Sheffield, 9. Description of Millspaugh group of companies, with details of paper-making machinery and general engineering products. Illustrated booklet published to record 21st anniversary of founding of parent company in England.

Pig Iron. LEIGH AND SILLAVAN LTD., Arkwright House, Manchester, 3. Cold blast, cast, hematite, and foundry pig iron; selling agents for metallic products including wirecloth, wire, cold rolled sections, tubes, steel bars, and pulleys. Illustrated booklet, giving brief details of wide range of services and products available.

Electronic Instruments. ROCKE INTERNATIONAL, LTD., 59 Union-street, London, S.E.1. Brüel and Kjaer instruments for electrical, acoustical, vibration and stress analysis, electrochemical and radioactive measurements. Illustrated catalogue giving brief particulars.

Gas in Industry. THE GAS COUNCIL, 1 Grosvenor-place, London, S.W.1. The uses of gas for heat treatment of metals, in glass manufacture, drying and finishing, chemical plant, wire making, food manufacture, ceramic drying and finishing, agriculture. Illustrated descriptive brochure.

Conveyor Pulley Wheels. CROFTS (ENGINEERS), LTD., Bradford, 3. Cast-iron conveyor pulleys for medium and heavy duty; single and double arm or plate centre construction; taper (convex) faced or flat faced pulleys. Illustrated leaflet with standard sizes and dimensions.

Speed Reducers. J. H. FENNER & CO. LTD., Hull. Torque-arm shaft-mounted speed reducers described in ENGINEERING of December 3, 1954, p. 742. Illustrated catalogue with tables of sizes and ratings, and tables of recommended V-belt drives.

Hydraulic Pumps. THE PLESSEY CO. LTD., Ilford, Essex. Applications of hydraulic pumps; basic body sizes and different assemblies obtainable, from 0·27 to 42 gal. per minute. Capacity proportional to speed. Two pamphlets, one with dimensioned drawings and displacement/speed graphs.

Sheet Metal Working Machines. F. J. EDWARDS LTD., 359-361 Euston-road, London, N.W.1. "Besco" sheet metal working machines, including guillotines, shearing machines, circle-cutting machines, folding machines, presses and rolling machines. Illustrated pamphlet.

Solderless Wiring Connection. THE PLESSEY CO LTD., Ilford, Essex. Crimping of cable terminal joints; light and heavy duty hand crimping tools, hydraulic crimping press unit; available for copper cables up to 280 amperes and for aluminium cables to 200 amperes. Illustrated booklet.

Bench Trays. PRECISION COMPONENTS (BARNET) LTD., 13 Byng-road, Barnet, Herts. "Kabi" interlocking bench assembly and storage trays. Illustrated leaflet.

Oil-Break Switch. A. REYROLLE & CO., LTD., Hebburn, Co. Durham. Oil-break switch type 33 P.I. designed for use with type L42T vertical isolation switchgear. Rating 33 kV, 400 amp., 750 MVA. Pamphlet 1279 gives full description.

BRITISH STANDARDS

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Lighting Transformer Units (air-cooled flameproof single-phase, supplied from high-voltage systems.) (2*s.*, post free.)

Prepared at the request of the National Coal Board, a new standard, B.S. 2538, covers transformer units intended mainly for the lighting of roadways in coal mines. It is stipulated that the standard primary voltage shall be either 2,200, 2,750, or 3,300 single-phase at a frequency of 50 cycles per second, and the secondary no-load voltage shall be either 125 and 250 volts or 115 and 230 volts. The standard rating shall be 2·5 and 5·0 kVA. The requirements relating to the transformers are laid down and the specification also contains clauses concerning earthing, incoming and outgoing cables, the primary isolating switch, primary uses, tests and other matters.

Wood Wool (for general packaging purposes). (2*s.*, post free.)

A new standard, B.S. 2548, specifies the dimensions, *p*H value, moisture content and other essential requirements of wood wool for general packaging purposes and also gives methods of test. Although wood wool is manufactured in a number of grades, the specification is confined to materials most commonly used for general packaging purposes; for example in connection with machinery, engineering equipment, furniture, glassware and ceramics. Packers are recommended to consult the newly-revised Section 12 of "Packaging Code," B.S. 1133, which deals with cushioning materials and suspension packing (excluding packaging felt) as it is pointed out that the Code gives guidance on the methods of using these materials.

Steel Pipe Fittings. (Two publications: B.S. 2051: Part 3, 3*s.* 6*d.*, and Part 4, 4*s.*, post free.)

Parts 3 and 4 of B.S. 2051 have now been published. Part 3 covers steel compression pipe fittings for engineering purposes and Part 4, steel nipple pipe fittings for brazing (Unified threads and Unified hexagons).

Part 3 applies to two ranges of fittings, namely, (i) that for use with pipes having fractional outside diameters, $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. inclusive and (ii) those for use with pipes designated by their nominal bores, $\frac{1}{8}$ in. to 1 in. inclusive. This standard does not attempt the complete dimensional standardisation of these fittings since the variety in the designs and methods of production, already established by various manufacturers, make any such attempt impracticable. The standard, however, does lay down such dimensions and requirements as are essential to ensure satisfactory installation and performance. A number of general requirements relating to materials, design, construction and workmanship are included, while a hydraulic test and a test for porosity are specified and the temperature and pressure ratings for these fittings are also given.

Part 4 provides for the complete dimensional standardisation of steel nipple fittings for brazing, of sizes ranging from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. inclusive, intended for use with fractional outside diameter sizes of tubes. The standard lays down requirements in respect of materials, dimensions, workmanship, hydraulic test, test for porosity, and identification marking. The maximum design pressures for these fittings are also given. Illustrations of the fittings and tables of dimensions are included.

Rotary Form-Relieved Gear Cutters. (7*s.* 6*d.*, post free.)

A new specification covering rotary form-relieved gear cutters, B.S. 2518, is intended to replace the original brief section on this subject in B.S. 122: 1938, which dealt with milling cutters and reamers. As a result of experience gained since the publication of B.S. 122, it became clear that the information there provided was inadequate and insufficient to ensure uniformity in the manufacture of gear cutters of the type involved. The new standard recommends the use of the 20-deg. pressure angle for gear milling cutters and a modified basic rack gear-tooth profile designed to avoid undercutting in gears having a small number of teeth, and also providing suitable tip relief in the teeth cut. An odontograph diagram with table of dimensions for 1 D.P. cutters is provided for the setting out of the correct profiles of the full range of cutters used in rotary gear-cutting practice for gears from a 12-tooth pinion to a rack. Tables giving details of cutter sizes for a range of diametral pitches of 1 to 30 are included.

The specification draws attention to the fact that gears cut with form-relieved cutters are satisfactory only if they are meshed together under conditions of service which are not severe. It is emphasised that such gears should not be made to mesh with generated gears unless a suitable reduction in the chordal tooth thickness of the gears is made. A correction table for this purpose is furnished in an appendix.

THE FUTURE DEVELOPMENT OF BRITISH COALFIELDS

Estimates of the total reserves of coal in Great Britain can do little more than confirm the general conclusion that there is plenty of coal left. Mr. E. H. Browne, Director-General of Production, National Coal Board, pointed out in his paper "The Coalfields of Great Britain and Their Future Development," delivered at the 61st Annual General Meeting of the Institution of Mining Engineers on January 27 in London, that no programme of development can be based simply on an estimate of reserves. Such a programme must be on a basis of economic reserves, and must take into account the questions of accessibility, rate of proving and rate of extraction in each area.

Mr. Browne went on to say that two facts stood out: firstly that the greatest output must come from areas which had already been explored, and secondly that very much of the best and most easily worked coal had gone. The depths of British collieries were steadily increasing, and all the new pits authorised since 1946 were in the range of 600 to 1,000 yards, whereas about 80 per cent. of the present output was from pits less than 600 yards deep. The aim of the National Coal Board is to increase production to an annual tonnage of up to 250 million, and this plan raises many complex problems. Stress must be laid on the extraordinarily wide range of geological conditions, which vary a great deal within individual fields; there can also be sharp differences between adjacent collieries. The wide variation in types of coal available will also have a considerable effect on development programmes. There is already a heavy demand for smokeless fuels and possible legislation may increase it. Naturally-smokeless fuels are only available in limited quantities, and there will not be enough of them to meet the demand. Consequently, it will have to be met, in the main, by manufactured fuels. The demand for carbonisation coals can be expected to increase, and the main reserves of this kind of coal are largely of low rank, and not particularly suitable for carbonisation by present techniques. As a result, it appears that the coking industry will have to be less exacting, and take coal of lower rank for blending. It is hoped that new developments in the gas industry will make gasworks more flexible in their choice of coal.

Mr. Browne continued with a detailed survey of the coalfields and outlined the present position and planned future developments in each one.

SCOTTISH COALFIELDS

The Lothians coalfield, on the south bank of the Firth of Forth, is perhaps the most attractive region for future development in Scotland, and it is planned to increase production there from its present level of 3·8 million tons to $5\frac{3}{4}$ million tons per annum in ten years. Two new collieries are planned. One is at Bilston Glen, which has an estimated reserve of over 100 million tons, while the other, at Monktonhall, will tap a reserve of 140 million tons. The Fife and Clackmannan field, on the north side of the Firth of Forth, is geologically continuous with

the Lothians field, but for various reasons it is unlikely that the underwater area will be worked, at least for a very long time. Present production is about 7 million tons a year and it is intended to raise it to towards 11½ million tons by 1965. New collieries at Seafield and Rothes, together with reconstructions at existing pits, and a possible further new sinking, will make this increase possible. The Central coalfield, lying mainly in the counties of Lanark and Stirling, has been very extensively worked in the past. The main Lanarkshire area is declining, and will continue to do so. Reconstructions at Kinneil and Valleyfield and a new colliery at Airth will enable mining to be continued in parts of the field, but on the whole, production will fall from the present level of 7½ million tons per annum to a little over 6 million tons in ten years. In the Ayr and Dumfries coalfield there are reserves which justify major expansion of the existing Barony Colliery and the sinking of a new pit at Killoch. Annual output, at present about 4½ million tons, is to be increased to just over 7 million tons by 1965.

The small coalfield at Canonbie, partly in Scotland and partly in England, is not worked at present, but boring by the National Coal Board has shown promise.

NORTHUMBERLAND AND DURHAM COALFIELDS

In Northumberland, the only large reserves remaining are in the north-central area, around Ashington and towards Blyth, though limited quantities of higher-rank coals remain in the south, and some development is to take place at Rising Sun Colliery. Important reconstructions are in progress at Lynemouth and other pits in the Ashington area, and at Bates. The present production is about 12¼ million tons a year, and it is planned to raise it to about 14 million tons in ten years. Later, it will decline. In west Durham much of the good coal has gone, and in mid-west and north-west Durham most of the output is from thin seams. In the south there are some appreciable reserves, but old workings in the south-west are flooded. The eastern part of the field will have to provide the expansion to offset the decline in the west, and there are big reserves here, but working is difficult, and much proving will be necessary. Six of the existing coastal collieries are being developed and a new shaft is being sunk at Hawthorn. Production to-day is about 26 million tons a year; no figure is given for future output.

CUMBERLAND COALFIELD

This field has an extremely complicated geological structure, and nearly all the coal to be worked in the future is under the sea. Workings at Haig Colliery are already 3½ miles from the coast, and it seems that the field will extend beyond the limits of practical mining. A scheme is in hand at Solway Colliery to prove the undersea coal in the northern part of the field, and it is hoped to maintain output from Cumberland at its present level of about 1¼ million tons a year. There is a possibility that the Coal Measures may extend to meet the southern part of the Canonbie coalfield, but any question of exploitation is dependent upon extensive exploration.

MIDLANDS

Nearly 40 per cent. of the coal mined in this country comes from the Yorkshire and East Midlands coalfield, and there are very big reserves. Yorkshire has large reserves of carbonisation coals, and produces first-class locomotive and household coals. A new colliery at Kellingley will tap reserves estimated at 240 million tons, and there are many big reconstruction schemes in hand at existing collieries. Present output is nearly 46 million tons a year, and the objective for 1956 is about 53 million tons. In the Nottingham and north Derbyshire coalfield large reserves have also been proved, and new collieries at Bevercotes, Cotgrave and Calverton, together with large reconstructions at existing pits, will enable output, at present 37½ million tons a year, to be expanded to 45 million tons in the next decade.

The older parts of the Lancashire coalfield, such as the Wigan area, are approaching exhaustion, and a general decline in production is inevitable. The bulk of the coal left is in the south, and reconstruction schemes are in hand at several collieries here, including Mosley Common, Astley Green, Bold and Bradford. A new pit, Agecroft, is also being sunk. Production is about 13½ million tons a year at present, and it is planned to be about 12 million by 1961-65.

In Flintshire the coal appears in a narrow coastal strip, which has mostly been worked out, and only one colliery survives. Here, at Point of Ayr, there are considerable reserves. In Denbighshire there are also reserves, but there is still much obscurity about the field generally, and it is only intended to raise the output slightly above its present figure of 2½ million tons a year.

The North Staffordshire reserves include large quantities of gas and coking coals. The best coals, however, lie at considerable depths, and mining conditions generally are difficult. Several reconstructions of existing pits and a new colliery will enable the output to be raised from 6¼ million tons a year at present to about 9 million tons, but it is not expected that this increase will be achieved by 1965, as originally hoped.

The southern part of the South Staffordshire field was celebrated for the Thick Coal, which is now largely exhausted. No developments are possible here, but the two remaining collieries should continue to raise about ¾ million tons a year for some time. In the northern part of the field, reconstructions, particularly at Littleton and West Cannock Collieries, and a new pit at Lea Hall, will offset the decline from the older part of the area and enable output to be increased from 5 million tons a year at present to 5½ million tons by 1965.

In the north and along the eastern flank of the Warwickshire field the best coal has been worked, but substantial reserves remain to the south and south-west. To the north boreholes have proved an extension of the field, but more information is needed. A large reconstruction scheme is in hand at Coventry Colliery, and several smaller reconstructions are taking place at other pits. Present output is about 5·4 million tons a year, and there should be no difficulty in maintaining this capacity, or increasing it a little.

To-day there is only one colliery at work in the Wyre Forest, and the small Shrewsbury coalfield has only a few thin seams of little importance. Reserves to the north-east of the Coalbrookdale area justify development of Lilleshall Colliery, but the output from the Shropshire field is, and will remain, small.

SOUTH DERBYSHIRE AND LEICESTERSHIRE COALFIELD

Explorations to the south-west have revealed a promising virgin area, the extent of which is not yet known. Output in this small field has increased remarkably in recent years, and is to-day about 8 million tons a year. Much of the coal, however, is not of very good quality, and the output is not expected to increase. New developments will probably take place in the Burton-on-Trent area, where borings have revealed a rich, though faulted field of coal.

SOUTH WALES COALFIELD

Most of this coalfield has been worked extensively for a very long period, but large reserves remain. The field is still of great importance because of the special coals it contains, which range from anthracite to coking coals and include some superb qualities. There is heavy faulting, and mining conditions in general are difficult. In the anthracite area, on the west of the field, new collieries are being sunk at Cynheidre and Abernant, and reserves have been proved in the Dulais Valley. In the dry steam coal area, east of the anthracite region, a large reconstruction at Mardy is nearly finished, and reconstructions in other parts of the field are planned or in progress. The output of anthracite is at present about 3 million tons a year, and it is planned to raise the figure to 4 million tons by 1965. The tentative long-term plan for this area is for an output of 6 million tons a year. In the steam coal and bituminous coal areas production is about 21 million tons annually; future developments are under consideration.

BRISTOL AND SOMERSET COALFIELD

The structure of this field is disturbed and complex, and it is only recently that boring by the National Coal Board has begun to reveal details of the concealed parts of the field. On the whole the area has fairly substantial reserves, but production is only about half a million tons a year at present, and future developments must await further explorations.

The Kent field is unique in Britain in being entirely concealed beneath younger rocks. Its possible existence was deduced about the middle of the last century, but development was commenced much more recently. The four existing collieries have ample reserves, and are being reconstructed to raise the total output from 1¾ million tons a year to perhaps 2¼ million tons. It is possible that a new pit will be sunk near Dover.

POSSIBLE NEW COALFIELDS

There are several areas on the outskirts of existing coalfields where developments may take place, and it is possible that entirely new fields may be discovered. Two new regions have been discovered in the East Midlands, though in one the coal is too deep for mining by present methods. In other cases the areas suggested have not been shown to contain the Coal Measures when drilled, and failures like this show that geophysical evidence must be considered very carefully before an intensive drilling programme can be started.

In conclusion, Mr. Browne said that there are very large reserves of coal lying under this island and in accessible coastal regions, but the problems of working them are formidable, and we need, among other things, improved techniques, methods of training and mechanisation, and, above all, better labour relations to provide the coal the country needs without excessive cost.

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MAUDSLAY SCHOLARSHIPS

Mechanical Engineering Training

Through the generosity of the Maudslay Society, the Junior Institution of Engineers are able to offer scholarships, which are to be known as Maudslay Scholarships, to young engineers to assist them in their technical education and practical training. The amount of any one scholarship will not exceed £400 per annum nor be less than £100 per annum and, initially, the scholarships will be tenable for one year. The scholarships are awarded by selection and, to be eligible, candidates must not have passed their 26th birthday and must be engineers or be training to be engineers wholly or mainly interested in mechanical engineering.

The holder of a scholarship will be known as a " Maudslay Scholar." The closing date for entries for this session is February 28 and further information can be obtained from the secretary of the Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1.

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MANUFACTURE AND USES OF PERMALI

A film entitled from " Strength to Strength " has been made by the Six Film Unit to demonstrate the uses of the various grades of Permali in the heavy electrical, steel, coal mining and textile industries. This material, which is made by Permali Limited, Bristol-road, Gloucester, is a wood laminate which is impregnated under vacuum with synthetic resin and has electrical and mechanical properties which render it suitable for many purposes where insulating strength and resistance to wear and fatigue are important.

The Engineering Outlook—4

THE MACHINE TOOL INDUSTRY

SHARP RECOVERY IN NEW ORDERS

After the very sharp fall in output in the first nine months of 1953 consequent on the virtual completion of the rearmament programme, the machine tool industry settled down to a fairly steady level of production, which was slightly higher than that for 1951 and nearly 20 per cent. above that for 1950, the last year before the influence of the armament programme began to be felt. Although there have been considerable differences in the experience of the various sections of the industry, output for 1954 for the industry as a whole was a good deal higher than was generally expected towards the end of 1953. This has been due for the most part to a recovery in home demand, exports having shown a continuous though slow fall since the first quarter of 1953.

It was in the third quarter of 1953 that new orders for machine tools reached their lowest level and some anxiety was expressed regarding the outlook. To some extent, however, the decline in orders was undoubtedly due to the long delivery date which the industry had been forced to quote owing to its preoccupation with armament requirements, and as in the case of shipbuilding the decline helped the industry to become more competitive. New orders from the home market began to recover in the fourth quarter of 1953 and continued to expand at an increasing rate throughout the past year, as can be seen in Table III. By the middle of 1954 total home order books were about £51 million, representing a little over one year's normal output for the home market, and export orders were about £19 million, again sufficient to provide work for a little over a year at the 1954 rate of exports. By the end of 1954 total orders on hand had reached about £75 million compared with a figure of £81 million in June, 1953, of which £24 million represented export orders. An encouraging feature of the new orders received in 1954 was that export orders increased proportionately at a higher rate than those from the home market and it was hoped by the end of 1954 that the long decline in export deliveries had been halted. The dislocation caused by the dock strike, however, prevents any definite conclusions being drawn from the export returns so far available.

In view of the expansion in output of the engineering industries as a whole and the need for further increases in productive capacity, particularly in the motor vehicle and ancillary industries, which are among the most important purchasers of machine tools, it is expected that the home demand for machine tools will continue to expand in the current year. In export markets two important developments, referred to in more detail below, which may be expected to exert a considerable influence on the industry's prospects are the decision to rearm Germany and the licensing of a substantial quantity of exports to Russia. It is not, of course, expected that Germany will become an important buyer of British machine tools, since it is generally accepted that German rearmament needs will be met mainly by the German machine tool industry together with some imports of specialised machines from the United States. Until further details are known it is impossible to forecast to what extent increased demand from the home market will absorb the capacity of German machine tool manufacturers, but at least in the early stages it may prevent an intensification of German competition in export markets. In the longer run, on the other hand, if the rearmament programme should necessitate an expansion of German machine tool capacity, the result may well be an intensification of international competition in, say, two to three years time.

Turning to consider United Kingdom deliveries of metal-working machine tools, shown in Figs. 1, and 2, too much importance must not be attached to the decline in the third quarter of the year since this is a seasonal feature which recurs each year and is due largely to summer holidays. Home deliveries, which represent the difference between the two charts for total and export deliveries in Fig. 2, were running above the corresponding figure for 1953 in both the second and third quarters of the year and the seasonal decline in the third quarter of 1954 was very much less marked than in the previous year. For the first nine months of the year, deliveries to the home market at £33·8 million were very slightly up on the £33·5 million of 1953.

As in the case of agricultural machinery, the expansion in new orders for machine tools for the home market undoubtedly owed a good deal to the tax allowances on new plant and equipment announced in the Finance Act, 1954, and this is likely to continue to influence the rate of replacement of machine tools during the current year. Some increase may also be expected in the new, as opposed to the replacement demand, since schemes approved for new factory building have been increasing steadily since early in 1952. In the first nine months of 1954 building schemes were approved covering new factories with a floor area of 50·2 million square feet which compares with 39 million square feet for the whole of 1953 and 26·7 million square feet for 1952. Although figures for the last quarter of the year are not yet available it is clear that the total for 1954 will exceed by a considerable margin the previous record total of 58·2 million square feet achieved in 1949. The time lag between the approval of plans and the completion of factories appears to average about two years since the peak figure for the area of new factories completed was not reached until 1951, and while the sharp rise in plans approved may have some effect on deliveries of machine tools in the current year, the full influence is likely to be deferred until 1956, provided, of course, that no developments occur in the meanwhile to prevent the realisation of the plans approved in 1954. As already mentioned, a considerable expansion programme is being undertaken by the motor vehicle industry and it has been announced that manufacturers of components for this industry are to spend £100 million on extensions to manufacturing plant.

EXPORT MARKETS

Exports of machine tools fell from 42,300 tons valued at £21·4 million in the first eleven months of 1953 to 35,550 tons valued at £18·4 million in the corresponding period of 1954. On a value basis, however, 1953 was a peak year for exports, and although the 1954 figure was lower than both of the preceding years it was nevertheless higher than for any other post-war year. In view of the intense competition experienced by most manufacturers in export markets, the figure is not unsatisfactory. Some of the credit for maintaining the competitive position of British manufacturers in export markets must undoubtedly go to the decision taken in 1951 to give a high priority to the maintenance of exports even though this necessitated a considerable volume of imports in the years 1951 to 1953 in order to meet the needs of the rearmament programme.

The import programme virtually came to an end in June, 1954, and this is reflected in a decline in imports of machine tools from 43,300 tons valued at £44·8 million in the first eleven months of 1953 to 15,800 tons valued at £14·8 million in the corresponding period of 1954. It will be noted that the average value per ton of the machine tools imported was very much higher than for exports; to some extent this was due to differences in the types of machine manufactured abroad compared with those exported, but it also reflects the high prices which it was necessary to pay for imports. In March, 1954, the Parliamentary Secretary to the Ministry of Supply told the House of Commons when the Civil Supplementary Estimates were considered on report, that an additional sum of £10·8 million was needed to meet increased costs for machine tools and ancillary tooling equipment bought by the Ministry from overseas in connection with the defence programme. The total number of machine tools supplied or to be supplied over the three-year period ending December 31, 1953, was 18,618 and there had been an average increase in price of 20 per cent. since the orders were placed. At that date only 630 machine tools remained to be delivered under the programme and these were due to arrive by the middle of 1954. About one-third of the total were obtained from the United States with the benefit of financial aid, and from Canada. The remainder had been ordered in Europe but no further orders had been placed under this particular scheme during the previous twelve months.

Of the imports in the first eleven months of 1954 about 23 per cent. consisted of milling machines and 12 per cent. of grinding, lapping and honing machines while other important categories included boring and broaching machines and lathes. The extent to which the defence programme inflated imports of machine tools is shown by the fact that in the three years prior to 1951 total imports varied between £5 million and £6 million. In 1954 the bulk of the imports were obtained from the United States (£4·7 million), Germany (£4·7 million) and Switzerland (£2·9 million).

United Kingdom exports of metal-working machine tools are shown in detail in Fig. 3 and Tables I and II for the first eleven months of each of the three years 1952 to 1954. It will be seen that there was a decline in exports to practically every country with the exception of Spain and Italy. Australia continued to be the largest individual market, followed by India, to which exports were fairly well maintained, and Canada. Fourth place was held by Spain and fifth by Italy both of which became more important markets than South Africa.

A disappointing feature of Table I is the marked decline in exports to the United States to little more than half the previous year's total. This was mainly due to a serious fall in total sales of machine tools in the United States. During the early months of 1954 these sales were running at only about half the 1953 level and new orders in April, 1954, were the lowest since the end of the Korean War. By June, 1954, orders on the books of United States machine tool manufacturers were equivalent to only about 4½ months output compared with 8½ months at the same period in 1953. Most of the new orders being received were for special-purpose tools, very few orders being received for standard tools.

In order to stimulate home sales and meet increasing competition from British and European manufacturers, the United States industry embarked on a sales drive of which one of the principal features is to be an exhibition prepared by the National Machine Tool Builders Association for 1955. In deciding to stage this exhibition United States manufacturers were influenced by the success of various exhibitions of imported machine tools at various machinery shows. The exhibition is to be held at Chicago in September, 1955, and will occupy about 450,000 square feet of floor space. United States manufacturers are hoping that sales will be stimulated by tax concessions in the form of increased depreciation allowances and that some way may be found to restore Government buying. One method suggested is by implementation of the Vance plan under which the United States Government would regularly buy and stockpile machine tools at the rate of about 250 million dols. per annum as an insurance against a national emergency. A special appro-

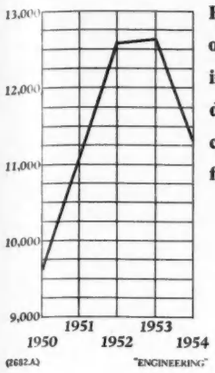


Fig. 1 U.K. deliveries of metal-working machine tools show an overall decline of about 10 per cent. in 1954. The figures are in average monthly tons.

priation of 250 million dols. was in fact made in 1953 for the production and stockpiling of the more complex tools which take a year or more to build, but was never used.

United States manufacturers were complaining during 1954 that their British and European competitors were guaranteeing to deliver tools to the United States within one month even though, in some instances, customers in other markets were obliged to wait for eight or nine months. In order to try and lessen the marked fluctuations of demand which have always been a feature of the machine tool industry, some United States manufacturers have been offering machine tools on a hire basis, though with an option to the customer to purchase at any time during the currency of the agreement (see Weekly Survey, October 22, 1954).

As will be seen from Table I, India is an important market for British machine tools; it is also a market with possibilities of very considerable expansion as the Indian industrialisation programme proceeds. The Indian Government is likely to encourage the production of machine tools in India but it must be a considerable time before the manufacture of the more complex types can be undertaken and demand must expand considerably as engineering capacity is increased to utilise the output of new steel plants now planned or in course of construction. One Indian company, Hindustan Machine Tools, Limited, is stated to have begun limited assembly of lathes in August, 1954, in conjunction with the Swiss Oerlikon Machine Tool Works,

RUSSIAN MARKET DEVELOPS

In considering the prospects for exports during the current year considerable hopes are pinned on development of the Russian market. In July, 1954, 150 applications for licences to export machine tools to Russia to a value of £26·7 million were under consideration by the Board of Trade and a considerable number of enquiries had been received for which applications for licences had not yet been made. In November, the President of the Board of Trade announced that 116 of these 150 applications had been granted during the past six months covering the export to Russia of machine tools valued at £11 million; applications covering £3 million worth of tools had been refused and seven of the remaining applications valued at £3 million had been withdrawn. If the exports for which licences have been granted are spread over the next two years they would make the U.S.S.R. by far the most important export market; the value of exports to this market in the first eleven months of 1954 was only £170,000 and in the corresponding period of 1953 £207,000. Before the war the U.S.S.R. was in many years the principal export market for British machine tools and to a very large extent fluctuations in the activity of the industry were due to variations in Russian purchases. Since then the capacity of the Russian machine tool industry has been very considerably expanded and it is probable that over the next few years British exports will not be as dependent on the Russian market as was the case before the war. Nevertheless it seems probable that exports to Russia during the next two years will amount to between one-third and one-half of total exports in 1954.

Apart from licensing restrictions on exports of machine tools to Iron Curtain countries, exports to a number of other markets are restricted by currency difficulties. This is particularly true of South America, which, as can be seen from Table I, has been a very disappointing market in recent years. There is, however, a large potential demand from both Argentina and Brazil, where British machine tools continue to enjoy a high reputation, but machine tool users are prevented from purchasing by currency restrictions and measures designed to foster local production.

TABLE I.—*United Kingdom Exports of Metal-Working Machine Tools by Countries (January to November)*

—	Quantities (1,000 Cwt.)			Value (£1,000)		
	1952	1953	1954	1952	1953	1954
Union of South Africa ..	97	88	60	2,001	1,990	1,350
India	61	90	73	1,149	1,822	1,762
Pakistan ..	15	15	27	342	297	718
Australia ..	162	171	122	3,459	3,585	3,210
New Zealand ..	19	18	18	440	437	458
Canada ..	105	121	61	2,691	3,150	1,456
Other Commonwealth countries and Irish Republic ..	46	52	40	1,008	1,235	929
Soviet Union ..	105	19	9	1,183	207	170
Sweden ..	23	18	17	707	513	471
Norway ..	10	8	8	202	196	185
Denmark ..	9	9	5	196	166	170
Netherlands ..	18	14	17	457	441	441
Belgium ..	11	19	7	308	597	248
France ..	29	34	33	817	1,105	973
Switzerland ..	6	7	5	212	245	171
Spain ..	7	12	61	191	425	1,381
Italy	41	29	36	948	846	1,376
Egypt	6	6	3	121	124	90
U.S.A. ..	68	58	33	1,870	1,533	880
Brazil	29	3	3	721	62	108
Other foreign countries ..	81	85	73	2,010	2,432	1,863
Total ..	948	846	711	21,033	21,398	18,410

TABLE II.—*United Kingdom Exports of Metal-Working Machine Tools by Types (January to November)*

—	Quantities (1,000 Cwt.)			Value (£1,000)		
	1952	1953	1954	1952	1953	1954
Boring ..	37	39	34	850	1,102	943
Drilling ..	93	87	63	1,765	1,806	1,348
Grinding ..	71	65	56	2,056	2,054	1,776
Lathes:						
Automatic ..	47	46	36	1,681	1,961	1,450
Capstan and turret ..	59	55	42	1,976	1,948	1,581
Other ..	117	106	78	2,823	2,704	1,970
Screwing and threading ..	13	12	15	586	562	722
Milling and gear cutting	44	60	55	1,479	2,105	1,870
Planing, shaping and slotting..	57	48	40	1,077	956	763
Presses:						
Hydraulic ..	48	38	29	702	583	563
Other ..	126	64	90	1,553	982	1,541
Punching and shearing ..	58	46	34	815	648	570
Others	89	88	65	1,862	2,019	1,713
Used, complete tools ..	45	28	32	540	357	271
Parts	44	64	42	1,268	1,611	1,279
Total ..	948	846	711	21,033	21,398	18,410

TABLE III.—*New Machine Tool Orders (£ millions).*

Quarters	Home	Export	Total
1951—			
First	17·3	7·6	24·9
Second ..	17·4	8·3	25·7
Third	11·9	6·4	18·3
Fourth	12·6	6·8	19·4
1952—			
First	11·1	6·4	17·5
Second ..	9·9	5·3	15·2
Third	7·6	3·6	11·2
Fourth	10·4	4·4	14·8
1953—			
First	9·5	3·0	12·5
Second ..	9·4	2·4	11·8
Third	8·8	2·9	11·7
Fourth	10·5	4·1	14·6
1954—			
First	10·9	4·2	15·1
Second ..	12·4	5·3	17·7
Third	14·2	6·0	20·2

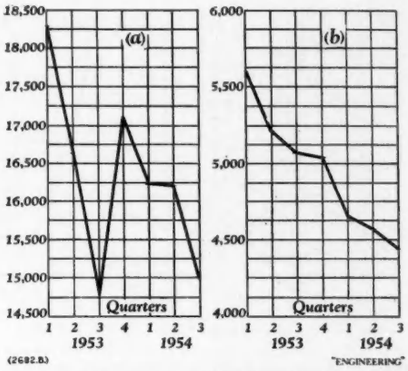


Fig. 2 Values of U.K. deliveries of machine tools for the four quarters of 1953 and the first three quarters of 1954 in £ thousands. Fig. 2 (a) shows the total value and Fig. 2 (b) the value of tools exported.

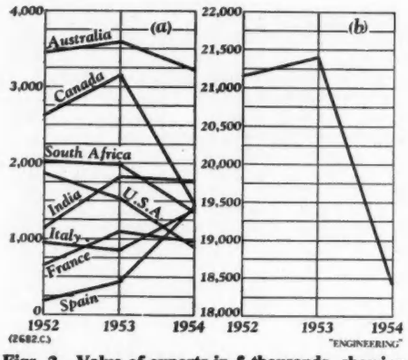
The division of United Kingdom exports of machine tools by types is shown in Table II. The most important categories are lathes of all types, milling and gear cutting machines, presses and grinding machines. The only category to show an increase in 1954 was that of presses other than hydraulic.

DEVELOPMENTS IN ORGANISATION

During 1954 there has been some further consolidation in the machine tool industry and in the related gauge and tool industry both in this country and throughout the Commonwealth. In June the chairman of the Coventry Gauge and Tool Company, Limited, announced that the company had acquired the whole share capital of the Pitter Gauge and Precision Tool Company, Limited. The products of the latter company were in many ways complementary to those of the parent company and the purchase provided the latter with a factory well sited to serve the London area. In the following month an agreement was made between Craven Brothers (Manchester), Limited, and Crossley Motors, Limited, a constituent company of Associated Commercial Vehicles, Limited, under which the Crossley Company will manufacture certain machine tools designed by Craven Brothers while the latter company will sell, instal and service them throughout the world. This development may be related to the statement of the chairman of Craven Brothers early in 1954 that the state of the company's order books was such as to assure a continuance of a very high rate of output throughout 1954, 1955 and 1956.

The Staveley Coal and Iron Company, Limited, which already held the majority of the shares of the Standard Machine and Tool Company, Canada, in July acquired the majority of the issued share capital of Modern Tool Works, Toronto. The Staveley Company announced that it was their intention that there should be the fullest collaboration and exchange of technical data between its British and Canadian machine tool companies, particularly as regards high production machinery for the motor vehicle and allied industries with a view to meeting the demand for machine tools in the Canadian and U.S. markets. Through its various subsidiary companies in the United Kingdom and Canada, the Staveley Company now manufactures a very wide range of drilling, milling, boring and planing machines, the English subsidiaries including James Archdale and Company, Limited, Cunliffe and Croom, Limited, and George Richards and Company, Limited.

Another company to extend their Canadian interests during the year was John Brown and Company, Limited, who acquired from A. C. Wickman (Canada), Limited, their business and assets relating to the manufacture of tungsten carbide equipment and their business as agents and factors of machine tools. The works acquired were stated to include full processing equipment for tungsten carbide and extensive



Figs. 3 Value of exports in £ thousands, showing totals for the eleven months January to November. Fig. 3 (a) shows value of exports to principal importing countries, and (b) total value of exports.

precision machine shops in Toronto. John Brown, of course, already had considerable interests in Canada through Firth Brown Steels, Limited, and Firth Brown Tools (Canada), Limited. New developments in cutting tools and drills exert an important influence on machine tool design and in this connection the opening of new research laboratories by Firth Brown Tools, Limited, at Sheffield in January, 1955, is an important development. The new laboratories, which occupy 7,000 square feet, were developed in order to undertake specialised work into all aspects of cutting of metal and powder metallurgy associated with the manufacture of tools for every type of engineering use.

Another company to extend its interests in the field of machine tool manufacture is T. W. Ward, Limited, who purchased in September, 1954, all the share capital of Frederick Town and Sons, Halifax, manufacturers of radial drilling machines.

Some British machine tool manufacturers were represented at the fourth European Machine Tool Exhibition held at Milan in September, 1954, at which about 800 manufacturers from 12 countries took part. The German industry was particularly strongly represented at this exhibition and the absence of some of the leading British manufacturers who were exceptionally busy at the time led to some unfavourable comparisons as regards the range of machine tools available from this country. British manufacturers will, however, be staging a comprehensive display of machine tools, many of them entirely new, at the International Machine Tool Exhibtion to be held at Olympia from June 22 to July 6, 1956, under the auspices of the Machine Tool Trades Association.

PROSPECTS FOR 1955

Taking the industry as a whole the general picture is a decline in exports during 1954 of about 15 per cent., partly counterbalanced by an improvement in deliveries to the home market with the result that total deliveries in 1954 declined by only about 10 per cent. These overall figures, however, conceal considerable variations in the experience of individual sections of the industry. The decline in orders during 1953 was more severe in the case of the simpler standard types of machine tools and a considerable range of these machines became available from stock. However, this section of the industry benefitted considerably from the revival of demand in the latter part of the year.

Manufacturers of the heavier and more complex types of machine tools and particularly of specialist machine tools for heavy electrical engineers, locomotive builders and heavy engineering generally were busy throughout 1954, and by the end of the year had exceptionally heavy order books in some cases amounting to three or four years work. It is believed that a substantial proportion of the Russian orders referred to above were in this category, since there has been a marked expansion in the Russian capacity to produce the more standard types of machine tool, e.g., capstan and turret lathes, largely as a result of assistance from the East German and Czechoslovak industries.

Another section of the industry which was working to full capacity during 1954 and has substantial orders on hand comprises the manufacturers of large unit machines for mass production. This section of the industry is likely to be called on to shoulder a further heavy load when the plans for expansion of the motor industry are completed. If the machine tool industry is to meet both home and export demand without unduly extending delivery dates it is important that manufacturers of motor vehicles and components should give the earliest possible notification of their requirements. While the machine tool industry showed in 1951 what can be done to meet an exceptional new demand by developing subcontracting and in other ways, the position is now more difficult on account of the higher level of activity throughout the engineering industries as a whole. In particular, it is doubtful how far the machine tool industry could expand the present labour force of 43,000 while there is also a serious shortage of designers and experienced draughtsmen. The extent of the problem can be seen from Table III, which shows new home and export orders received up to the third quarter of 1954. It will be seen that in the third quarter of 1954 new orders for the home market were the highest recorded since the second quarter of 1951, while new export orders were the highest since the first quarter of 1953. In the second and third quarters of 1954 home and export orders together exceeded deliveries of machine tools by £6·7 million. If this were evenly spread over the industry as a whole it would represent an extension of delivery dates by about five weeks; in practice, a high proportion of the increase consists of orders for the more complex types of machine tool for which order books were already very heavy.

It would seem that all sections of the industry may look forward to a high level of activity during 1955 since the full effect of the increase in new factory building and of the expansion plans of the motor vehicles industry has not yet been felt. It must not, however, be overlooked that the machine tool industry is always very sensitive to changes in the industrial barometer and any change in the confidence of British or overseas industry in general as regards future prospects might be quickly reflected in a decline in demand for machine tools. Although at present orders in hand amount on the average to well over a year's output of the industry it is impossible to say what proportion of these might be cancelled in the event of a recession in industrial activity.

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ELECTRICITY SUPPLY IN DECEMBER

Substantial Increases

During December, 1954, 6,691 million kWh were sold by the British Electricity Authority to the Area Boards. This was an increase of 12·8 per cent. over the figure for December, 1953. When corrected for the weather conditions, which were colder than a year earlier, and for the number of effective working days, which were less, the increase was 11·7 per cent. The total amount sold during the year ended December 31, 1954, was 66,109 million kWh, or 9·6 per cent. greater than in the previous twelve months after the necessary adjustments had been made.

The amount of electricity sent out by the Area Boards during December, 1954, was 6,544 million kWh, while 147 million kWh were supplied direct by the central Authority. The increases in the amounts sent out, compared with the corresponding figures in December, 1953, were 11·3 per cent. in the " mainly industrial " and 13·1 per cent. in the " mainly non-industrial " areas.

LAUNCHES AND TRIAL TRIPS

M.S. " KHUZISTAN."—Single-screw cargo vessel, with accommodation for five passengers, built by John Readhead and Sons, Ltd., South Shields, for the Strick Line Ltd. (Managers: Frank C. Strick & Co., Ltd.), London, E.C.3. Main dimensions: 450 ft. between perpendiculars by 58 ft. 6 in. by 32 ft. 2 in. to upper deck; deadweight capacity, about 9,600 tons on a draught of 25 ft. 8 in. N.E.M.-Doxford four-cylinder opposed-piston oil engine, developing 4,400 b.h.p. at 115 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, about 13 knots. Trial trip, January 11.

M.S. " LOTTE SKOU."—Single-screw cargo vessel, with accommodation for ten passengers, built and engined by Burmeister and Wain Ltd., Copenhagen, for the joint ownership of Ove Skou Ltd. and The Shipping Co. of 1937 Ltd., both of Copenhagen, Denmark. Main dimensions: 365 ft. between perpendiculars by 55 ft. 6 in. by 35 ft. 4 in. to upper deck ; deadweight capacity, 6,550 tons on a draught of 24 ft. 3 in.; cargo capacity, about 395,000 cub. ft. (bales). B. and W. nine-cylinder single-acting two-stroke Diesel engine, developing 5,400 b.h.p. at 150 r.p.m. Engine is arranged for burning Diesel and heavy oil. Delivered, January 3.

M.S. " PERANG."—Single-screw cargo vessel, built by William Gray & Co., Ltd., West Hartlepool, for the Elder Dempster Lines, Ltd., Liverpool. Main dimensions: 425 ft. between perpendiculars by 60 ft. by 38 ft. to shelter deck ; deadweight capacity, 10,060 tons on a draught of 26 ft. 0⅜ in. Scott-Doxford four-cylinder Diesel engine developing 2,800 b.h.p., constructed by Scotts' Shipbuilding and Engineering Co., Ltd., Greenock, and installed by the shipbuilders. Service speed, 11½ knots. Trial trip, January 10.

S.S. " SIR JOHN SNELL."—Single-screw self-trimming collier, built by Hall, Russell & Co., Ltd., Aberdeen, for the British Electricity Authority, London, S.W.1. (Managers: Stephenson Clarke Ltd., London, E.C.3). Main dimensions: 323 ft. between perpendiculars by 43 ft. 3 in. by 20 ft. 3 in.; deadweight capacity, about 3,700 tons on a draught of 18 ft. Triple-expansion steam engine of reheat design, developing 1,475 i.h.p. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Steam generated by two oil-fired cylindrical boilers. Launch, January 11.

M.S. " TALARA."—Single-screw oil tanker, built and engined by Burmeister and Wain, Ltd., Copenhagen, Denmark, for the Direccion General de Administration de Marina, Lima, Peru. Main dimensions: 335 ft. 10 in. by 50 ft. 10 in. by 22 ft. 6 in.; deadweight capacity, 4,800 tons on a draught of 19 ft. 1½ in.; oil-tank capacity, 5,500 cub. metres. B. and W. five-cylinder single-acting two-stroke oil engine, developing about 2,200 b.h.p. at 115 r.p.m. Speed, 12½ knots. Delivered, December 31.

S.S. " BALLYLAGAN,"—Single-screw collier, built by Austin and Pickersgill, Ltd., Sunderland, for John Kelly, Ltd., Belfast. Main dimensions: 224 ft. by 34 ft. 3 in. by 15 ft. to upper deck; deadweight capacity, 1,445 tons on a mean summer draught of 14 ft. 7¼ in. Triple-expansion direct-acting surface-condensing steam engine, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Steam supplied by one marine oil-burning boiler. Speed, 9½ knots. Trial trip, January 17 and 21.

M.S. " OWERRI."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Harland and Wolff, Ltd., Belfast, for Elder Dempster Lines, Ltd., Liverpool. Main dimensions: 425 ft. between perpendiculars by 62 ft. by 34 ft. to shelter deck; gross tonnage, about 6,240. Harland and Wolff-B. and W. five-cylinder opposed-piston Diesel engine. Trial trip, January 20.

M.S. " DEMODOCUS."—Single-screw cargo and passenger-carrying vessel, built by Vickers-Armstrongs Ltd., Walker-on-Tyne, for Alfred Holt & Co., Liverpool. Main dimensions: 487 ft. overall by 62 ft. by 35 ft. 3 in.; gross tonnage, about 7,800; deadweight capacity, about 9,000 tons on a draught of 28 ft. Harland and Wolff-B. & W. six-cylinder supercharged Diesel engine, developing 8,000 b.h.p., constructed by Harland and Wolff, Ltd., Belfast, and installed by the shipbuilders. Launch, January 24.

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In an article on the Report of the Chief Inspector of Factories for 1953, published in the issue for January 7, 1955, on page 8, the number of fatal electrical accidents in factories was incorrectly stated to have been 70; the number was in fact 40.

MINIATURE CIRCUIT-BREAKERS*

THEIR DESIGN, PERFORMANCE AND APPLICATION

By H. W. Wolff, B.SC., *and T. G. F. Atherton*, B.A.†

The development of the miniature circuit-breaker has been due to the need for a protective device embodying the small size and cheapness of the fuse with the dependability and re-switching features of the circuit-breaker. Some of the requirements it has to meet are hard to reconcile. It must be inexpensive and preferably no larger than a fuse of corresponding maximum rating. It must be suitable for mass production and thus be capable of easy assembly by semi-unskilled labour. As a switch it must be capable of making and breaking its rated current faultlessly a great many times. As a circuit-breaker it must give reliable protection against dangerous overloads and short-circuits.

Where miniature circuit-breakers are used in lieu of fuses they will normally be in the " on " position and the one essential mechanical condition is non-deterioration. On the other hand, when used in lieu of a switch or switch-fuse, they may be called upon to make and break circuit a number of times and a minimum life of 15,000 operations at 5 amperes, as laid down in the British Standard specification for tumbler switches, should give a value that may be achieved and even considerably exceeded. The mechanism should be trip-free, so that it cannot be held closed against a fault, and should withstand impact and vibration of at least moderate severity.

ELECTRICAL REQUIREMENTS

As regards electrical requirements, currents up to the maximum rating must be carried without overheating and undue loss. In order to keep the voltage drop across the contacts to a minimum, some rolling or wiping action is generally incorporated. To reduce the size of the contacts to a minimum and to eliminate skilled fitting there has been a tendency to adopt butt contacts. Tripping must be ensured on serious maintained overloads, but must not occur on harmless short surges. Speedy re-setting of any time-delay employed may be required. On severe overloads and short-circuits tripping must be instantaneous. To quench the arc set up by substantial fault currents contact arrangement is difficult, particularly as the gap is usually no more than a fraction of an inch. Arc chutes, blow-outs and arcing contacts are all used for this purpose.

AUTOMATIC TRIPPING

Owing to the size difficulty, much thought has been given to automatic tripping devices and these may be either instantaneous or delayed. The former invariably operate on the electromagnetic principle and are required in all cases to give protection against heavy faults. They may also be used for ordinary overload operations, when it is desired to give immediate protection to a circuit. In most cases, however, the provision of some delay is desirable and is, in fact, essential to prevent tripping on harmless short-lived overloads, such as starting and switching surges. These time-delay devices are either of the bi-metal strip or electromagnetic types, working on the hydraulic dash-pot principle, the speed of operation in both cases being a function of the current. The former are simple and cheap to manufacture, can be made of very small dimensions and arranged for easy calibration and subsequent adjustment.

On the other hand, an electromagnetic time-delay can provide both delay on overloads and instantaneous operation on short-circuit, whereas a thermal element requires a separate electromagnetic trip for the latter purpose. Some ingenious, yet simple, combinations of thermal time-delay and electromagnetic instantaneous trips have been devised. There is little to choose between the two types as regards consistency of operation, but electrically operated dash-pots have the advantage that they can be built up as sealed units free from external interference. An arrangement of this kind, which has been specially designed for incorporation in miniature circuit-breakers is described in the paper.

RUPTURING CAPACITY

The exact rupturing capacity of a miniature circuit-breaker may be considerably affected by small details of design. It is therefore difficult to quote exact values. In addition, it is necessary to provide some criterion which clearly states when a test may be considered satisfactory. After the clearing of a fault a miniature circuit-breaker should not have to be examined as is usual with large circuit-breakers. Two values have therefore to be considered, the " actual " rupturing capacity and the " useful " rupturing capacity, which is likely to be appreciably lower. It may be taken as a general guide that the maximum alternating current rupturing capacity of existing miniature circuit-breakers is about 1 MVA per pole per phase down to power factors of about 0·5, the speed of clearing these high currents being about 10 milliseconds. It is unlikely that a miniature circuit-breaker will clear its maximum rupturing capacity more than 3 to 6 times without appreciable reduction in its efficiency. The rupturing capacity of a given design is independent of the particular current rating tested. The " useful " rupturing capacity will be one half to one quarter of the " actual " rupturing capacity, so that the fault may be cleared from 50 to 100 times without ill effects to the operating efficiency. This is not serious since the prospective short-circuit current in the great majority of applications lies considerably below these figures. On a direct-current supply the rupturing capacity will normally be one quarter or less of the alternating current value for a given voltage. To compensate for this it is common practice to reduce the direct-current rating to half the alternating value, the operating time remaining at 10 milliseconds.

The making capacity of a miniature circuit-breaker is likely to be lower than its maximum rupturing capacity and to have about the same value as the " useful " rupturing capacity. The reason for this difference lies mainly in the absence of contact pressure on " making." The absence of contact wipe, with a consequent risk of welding, when making on a fault is a contributory factor. This can be overcome by using a carbon-tipped arcing contact.

OPERATING FEATURES COMPARED

British Standard specification No. 88 of 1952 provides that Class Q fuses shall have a maximum fusing factor of 1·75 for the high rupturing capacity and of 2 for the re-wireable types. Comparing these characteristics with those of miniature circuit-breakers with magnetic-hydraulic and thermal-magnetic trips it is found that in the region of minimum fusing current the circuit-breaker time delays, and particularly the magnetic-hydraulic delays, are much shorter and more consistent. Consequently, a more accurate degree of protection is obtainable. A properly designed and sealed circuit-breaker overcomes the danger of misuse (which may occur with a fuse), since once interrupted the circuit cannot be reinstated if fault conditions continue.

Since the war the use of small circuit-breakers has spread with surprising rapidity and examples are given of their applications to power, distribution and domestic circuits. They compare favourably with fuses as regards the simplicity and speed with which a circuit can be reinstated at negligible cost. For instance, it took 50 minutes to reinstate the circuit when a fuse blew in an operating theatre in a large London hospital. Moreover, not only is there frequent difficulty in determining exactly which fuse has blown, but there is a widespread habit of replacement before the faulty circuit has been checked. This is apt to be expensive when dealing with a persistent fault. An immediate attempt to reinstate a circuit protected by a miniature circuit-breaker can be made in safety, at negligible cost; and its success or failure indicates whether or not the attention of a skilled man is required.

SOME ECONOMIC FACTORS

As regards the relative economies of fuses and miniature circuit-breakers, if the initial cost of a 15-ampere single-pole and neutral switch fuse is taken at 100, that of a corresponding miniature circuit-breaker will be 158. The initial cost of a similar 50-ampere fuse will be 386 and that of the corresponding miniature circuit-breaker 165. The answer to the question whether the savings in maintenance will cover the difference in initial cost is not easy, but an investigation of an installation containing nearly 200 distribution boards catering for some 2,000 fused circuits rated between 15 and 60 amperes showed that 462 fuses were expended in 27 months and in no instance was the fault more than transient. These figures represent a considerable cost in labour and material. The cost of loss of production may also be considerable and may outweigh all other factors.

The authors feel that there is scope for the development of small circuit-breakers for particular applications and that the more widespread their adoption the more far-reaching will be the effect on maintenance costs. It therefore seems likely that they will occupy a place of constantly increasing importance in the field of small protective switchgear.

* Paper read before the Utilisation Section of the Institution of Electrical Engineers on Thursday, January 20. Abridged.

† Mr. Wolff is with M.C.B. Company, (Manchester) Limited, and Mr. Atherton with Dorman and Smith, Limited.

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MEASURING AND CONTROL APPARATUS

Association Luncheon

Developed from a war-time association, the British Industrial Measuring and Control Apparatus Manufacturing Association has grown to include 32 member firms representing 90 per cent. of the industrial instrument capacity of this country. Speaking at the annual luncheon held on January 18, at Londonderry House, Park Lane, London, W.1, Sir Edward Boyle, the Parliamentary Secretary to the Ministry of Supply, recalled the Association's work for the benefit of the industry, and drew attention to the shortage of trained men and mechanics for operating and servicing industrial instruments. In a later speech, Sir Roger Duncalfe, President of the British Standards Institution, said that the logical growth of instrumentation was to instrumental control and the automatic factory. Drawing attention to the Beaver Report on Air Pollution, for which he had been deputy chairman, Sir Roger emphasised that smoke could be stopped almost completely; but for this the first requirement would be the fitting of control instruments.

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LONG-LIFE DOUBLE-TRIODE VALVE

A low-impedance double-triode valve with a life expectancy of over 10,000 hours has been introduced by Mullard, Limited, Century House, Shaftesbury-avenue, London, W.C.2. Designated the E90CC, it is particularly designed for high-speed switching circuits. The peak emission is 75 milliamperes and the characteristics are closely controlled.

DESIGNING OPEN-HEARTH FURNACES

The Influence of Fuels

In the course of a paper on the design and construction of open-hearth furnaces, presented before the West of Scotland Iron and Steel Institute in Glasgow on January 21, Mr. J. L. Adamson, of the Wellman Smith Owen Engineering Corporation, Limited, said that from the furnace designers' point of view, rich fuels such as oil or coke-oven gas were preferable since they were delivered to the open-hearth furnace end at high pressure and consequently they entrained the necessary combustion air by virtue of their jet effect. A simple port-end construction was thus possible as there was no need to be concerned with the necessity for deflecting air into the fuel stream, as was required on a producer-gas-fired furnace. In some instances, provision had to be made for the use of alternative fuels and the task of the designer became more difficult. A furnace which had to be designed for oil and producer gas presented a very complicated problem and in such an instance it was preferable to build the furnace for one fuel, with the provision for easy port-end modification when a change of fuel became necessary. A furnace could be designed efficiently for one fuel only and the cost of partial re-building would be offset by the increased thermal efficiency obtained.

In the matter of furnace capacity, experience suggested that ordinary commercial steels could be made in any size of furnace although the economics of the process tended to indicate that the larger sizes were preferable. It appeared, on the other hand, that alloy steels were best made in small or medium-sized foundries where a closer metallurgical control could be observed. It had been ascertained that about 6 square feet of bath area per ton of furnace capacity would give a fast-operating furnace on cold charging. Bath width was determined either by the charging machine or the stability of the refractory roof. Most open-hearth furnaces had spans of less than 20 ft. from skewback to skewback. A maximum bath length of 50 ft. appeared to be the limit. Larger baths than this would probably lead to considerable variations in furnace temperature which was not conducive to good operation.

The number of charging doors was determined by a combination of two factors, namely, charging-box size and bath length. Open-hearth furnaces invariably had three or five doors, although there had been reports of furnaces operating with the front wall built in such a manner that it was virtually one door. The choice of three or five doors was also related to the ease of fettling, and the brick pillars that separated the doors. Since it was not unknown for a charging machine to damage the front pillars, the design of these should enable standard bricks to be used, of such a size as to make hot patching a satisfactory task.

From the designer's standpoint a deep chequer chamber was the ideal system for the regenerators, but existing sites did not allow much latitude in this respect and the ever-present problem of drainage level invariably meant building a compromise chequer system. All flues should be designed to give the minimum pressure drop possible. This meant the streamlining of the flues and the installation of straight-through valves. In many plants provision was made for the blowing of the flues with compressed-air or steam.

The application of instruments to an open-hearth furnace could be arranged in the design but their subsequent efficiency of operation was entirely the responsibility of the melting-shop staff. Most plants possessed such instruments as furnace-pressure control indicators, flow meters for the furnace fuel and the air, audible and visual means of determining the reversal times for the chequers, and roof-temperature indicators.

CRACKING OF STEAM PIPING

COMPARISON BETWEEN 0·5 PER CENT. MOLYBDENUM AND CHROMIUM MOLYBDENUM STEELS

The problem of cracking, in service, of 0·5 per cent. molybdenum-steel steam piping has been the subject of an investigation by sub-committee J/E of the British Electrical and Allied Industries Research Association. Pending the results of this investigation, the committee prepared certain recommendations (reported in ENGINEERING, *vol. 162, page 209, 1946), the observance of which, it was considered, would reduce the risk of cracking. A full report has now been issued,* which not only records the results of investigatory work but also examines the incidence of steam-pipe failures in a number of power stations. This report is only available to E.R.A. members, but the following is a summary.*

A number of casts of steel of varying composition were specially made to eliminate, as far as possible, factors which might arise by variations in steelmaking technique and these were used for the majority of the laboratory tests. In addition, tests were also made on material from steam pipes which had failed in service. The main items explored were a comparison of 0·5 per cent. molybdenum and 1 per cent. chromium-molybdenum steels, the effect of the carbon content in 0·5 per cent. molybdenum steel, the effect of surface irregularities, and the effect of intermittent heating and loading as occurred in a two-shift station.

The laboratory tests generally showed no substantial difference in creep and rupture strength between the chromium-molybdenum and the 0·5 per cent. molybdenum qualities. One important and oustanding difference, however, was the markedly greater elongation, at rupture, of the chromium-molybdenum steel.

Stress-rupture tests on a 0·5 per cent. molybdenum 0·07 per cent. carbon-steel steam pipe which had failed in service, using unnotched and notched test specimens, showed that this material was superior to the experimental steels of similar and slightly higher carbon contents and it is concluded that there is nothing abnormal about the steam pipe as regards high-temperature strength.

CARBON CONTENT

It had been suggested that failure might be associated with low carbon content, and tests on the series of experimental steels with varying carbon contents suggested that the 0·5 per cent. molybdenum 0·11 per cent. carbon steel used for comparison with the 1·0 per cent. chromium 0·5 per cent. molybdenum steel was abnormal and the former's rupture strength was not comparable with the other 0·5 per cent. molybdenum steel. The carbon-content tests showed that some benefit is to be derived from an increased carbon content if the stresses are high because, in some cases of failure of low-carbon molybdenum steel, cracking occurred where there was abnormally high local tensile stresses.

The results of tests carried out to investigate the effect of repeated loading and heating gave definite indications that, when the stress was high, such cycles were somewhat detrimental to both the 0·5 per cent. molybdenum and the chromium-molybdenum steels but, at lower stresses, little effect was observable.

It was considered that the only way to investigate the effect of surface irregularity was by producing a controlled degree of stress concentration by means of notches in the test specimens, and a comparison of tensile rupture tests on unnotched and notched specimens indicated, in general, a decrease in rupture life in the presence of a notch.

None of the other factors examined, such as the effect of local surface damage or of decarburisation, had a significant effect on the rupture strength or gave a definite lead in connection with the problem of discriminating between different steels.

* Report Ref. J/T160 of the British Electrical and Allied Industries Research Association.

STRESS-RELIEF TREATMENT

It was considered desirable to examine the response of the 0·5 per cent. molybdenum and the chromium-molybdenum steels to stress-relief treatment and this work showed that the stress-relief treatment at 620 deg. C., recommended in the precautionary measures previously referred to, would produce about 70 per cent. reduction in stress. (Initial maximum stress in bending 10 tons per square inch.)

The survey of service experience covers six power stations, of which four were essentially continuous-service stations, designated B, C, E and F, and two, designated A and D, operated under the two-shift system. The total number of failures of the type under examination was 47, of which 40 occurred at the two-shift stations, 37 being at station A and three at station D, which is a relatively new station, so that this number of failures cannot be taken as a true indication of behaviour, under the conditions at this station, until more information is available.

At station A, the plant was shut down nightly and the temperature of the steam in the piping system fell from approximately 910 deg. to 480 deg. F., or lower. Subsequently, when starting up on the morning shift, it rose steeply to 910 deg. F. in about half an hour. In addition to this daily change of temperature, there were quite frequent temperature swings above the design temperature, many of which exceeded 1,000 deg. F. There is considerable evidence that the conditions at this station have impvoved considerably during the last few years.

EFFECT OF TWO-SHIFT OPERATION

All the pipes which failed at this station were, with one exception, of low-carbon 0·5 per cent. molybdenum steel with an average of about 0·07 per cent. carbon and, as stated previously, it had been suggested that a low-carbon content might be associated with failure, but this one exception is very significant. This pipe, with a higher carbon content of 0·14 per cent. had originally been made for station B, in which the piping system was similar to station A. No pipes have yet failed at station B, which operates continuously, but the transferred pipe failed at station A, so that material of one supply, which has proved satisfactory under continuous load has failed under two-shift operation.

No case of intergranular cracking in 1 per cent. chromium, 0·5 per cent. molybdenum steel has been reported, but there does not appear to be any station with piping wholly of this type of steel working under two-shift conditions such as were in operation at one time at station A. All the later failures at this station have been replaced by pipes made from chromium-molybdenum steel and no failure of the steel has been reported. This limited experience suggests that the chromium-molybdenum quality is better able to meet the intermittent conditions operating at station A, but it is not conclusive because the operating conditions at station A have been improved and it is recommended that further trials be made on this quality of steel.

CONCLUSIONS

It is reported that the incidence of steam-pipe failures of 0·5 per cent. molybdenum steel is largely associated with two-shift operation in which additional stresses arising from thermal action are imposed during each heating and cooling cycle. The committee recommend, therefore, that steps be taken to reduce, as far as possible, the thermal stresses arising on heating

and cooling and that the measures, which were previously recommended to reduce the risk of cracking, should still be observed.

In several cases of cracking of 0·5 per cent. molybdenum steel in service there was evidence that abnormal local stresses had been a contributory factor. The experimental work revealed that although there was no substantial difference in rupture strength at service temperatures between (*a*) 1 per cent. chromium, 0·5 per cent. molybdenum and (*b*) 0·5 per cent. molybdenum steels, the former possessed markedly greater elongation at rupture. Where high local stresses have to be accommodated it seems probable that the 1 per cent. chromium, 0·5 per cent. molybdenum steel is better able to do this than the 0·5 per cent. molybdenum steel. Experience with chromium-molybdenum steel under intermittent working has been satisfactory, and it may be that the difference in ductility which has been associated with improved resistance to cracking, has an important effect on the serviceability under such conditions. Although the evidence is incomplete it appears to the committee that the 1 per cent. chromium, 0·5 per cent. molybdenum steel is superior to the 0·5 per cent. molybdenum steel for service where repeated variations of high stress and temperature may occur.

In the light of present experience it is recommended that where two-shift conditions are, or are liable to be, in operation the chromium-molybdenum steel should be chosen in preference to the 0·5 per cent. molybdenum quality.

INTEGRAL STRUCTURES

THE METALLURGIST'S POINT OF VIEW

Following closely after the conclusion of the Aircraft Production Conference, which was reported in our two previous issues, another viewpoint on integral construction was presented in a lecture entitled "The Manufacture of Integral Structures," by Dr. E. G. West, technical director of the Aluminium Development Association, before the Royal Aeronautical Society on January 18. In his lecture Dr. West surveyed the methods available for producing elements of integrally stiffened structures, and discussed the metallurgical and technological problems which have to be solved before large-scale production can be undertaken. We give below a synopsis of the lecture, which Dr. West has prepared for us.

The methods of producing large elements of integral structures are extrusion, "sculpturing" from the solid plate by various methods, forging, rolling of ribbed sheet and, occasionally, casting. Machining may be by developments of normal techniques, by chemical or electro-chemical removal of unwanted metal, and in the case of tapered sheet, by wet abrasion.

CHEMICAL "MACHINING"

Sculpturing by chemical means allows the use of equipment of low capital cost and allows complex "cuts" to be made by suitable masking. Although the method is sufficiently new to appear perhaps impracticable to production engineers, it is worthy of full investigation, and possibly has a special initial application to prototype work.

Press forging has attracted perhaps more attention than any of the other methods, partly on account of the very large capacity equipment required. The difficulties of rolling ribbed sections are considerable, particularly when the close tolerances required for aircraft are taken into account, but the possibilities of producing ribbed sheet by some welding process require further exploration. The production of integral structures by casting, attractive from the production point of view, is not favoured by the designer since the strength-to-weight ratio is too low. Closely allied to these methods are the many forms of sandwich construction.

In applying these methods, firstly, sufficiently large blocks must be cast to give the required dimensions after fabrication. For example, plates 4 in. thick, by 6 ft. wide and some 30 ft. long would necessitate casting a billet of about 5 tons—certainly much above those already produced for either commercial or aircraft purposes. Secondly, the heating and soaking of such large blocks for hot-working operations introduces serious problems of furnace design and construction, coupled with exact control of heating rates. The extrusion of hollow sections for ribbed sheet sufficiently large to make their adoption worth while demands extrusion presses of capacity up to 30,000 tons or more. For satisfactory sections of such dimensions, special methods of producing the cast billets are required, such as the semi-continuous casting process, but the handling, machining and pre-heating of such large billets involve formidable new problems. Likewise big forgings require presses of enormous size and much experience in their operation is essential.

Having rolled the thick plate, or extruded the large section, or pressed the big forging, the problem of straightening must be faced, and again this requires very large and heavy equipment. Machining is also dependent on the handling and holding facilities available, whilst forming the machined panels to the desired contour requires further development work, for example, on the stretching press, which may have to be operated hot in order to form the stronger alloys satisfactorily. A possible alternative is to form them in the freshly solution-treated condition which, on a production basis, would involve the provision of large-scale refrigeration equipment to maintain the alloys soft.

Finally, attention must be turned to the heat-treatment plant necessary to solution-treat and precipitate the strong alloys. Not only must the plants be large in relation to most present-day equipment, but the control of the temperature distribution within the heating chamber, the rate of heating, the means of supporting the work at temperature, and the means of removing it for quenching, all involve new problems.

In spite of difficulties the problems are being solved and their solution should open up a range of fascinating possibilities for the aircraft designer. It is, however, essential to devise and co-ordinate a programme of investigation into the problems of production, including equipment design, metallurgical factors and the efficient use in the aircraft structure of the largest components capable of manufacture. Some measure of tentative standardisation of a relatively few forms of ribbed sheet, extruded stiffened sections, and even forged panels, would facilitate the production of integral structures for full-scale trial purposes.

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WEAR OF CHROMIUM-PLATED CYLINDERS

Endurance Tests on a Small High-Duty Diesel Engine

On January 20, Mr. B. W. Millington, who is in charge of Diesel-engine development at Ricardo and Company (1927), Limited, Shoreham-by-Sea, presented to the Diesel Engine Users' Association a paper entitled "Life Tests on a Small High Duty Engine with Particular Reference to Chrome Bores." In this he described a series of tests carried out under the auspices of the Admiralty on a single-cylinder Diesel engine, the prototype of a multi-cylinder supercharged engine. The engine had a bore of 5 in. and a stroke of 5½ in. and was arranged so that it could be either supercharged or normally aspirated, and the exhaust could be throttled to represent the "snort" running of a submarine. The engine was coupled to a swinging-field dynamometer which acted as brake and starter.

Mr. Millington began by describing some special techniques used in connection with the tests. The temperature of the cylinder liner had been measured with a Ricardo traversing thermocouple, from which the temperature gradient and therefore the local heat flow could be derived. It had also been necessary to measure the radial wear of the cylinder and this had been done with a dial gauge, the leg of which slid on a surface held parallel to the cylinder axis while the stylus passed over the worn surface. Two methods had been used to measure the cylinder surface finish, both employing plastic replicas which were afterwards examined on a profilometer. Both methods, however, suffered from the fact that the plastic cement used contracted on drying.

The author then proceeded to detail the series of tests that had been carried out, and described the two standard test conditions that were used. The first was "full power" with the engine supercharged at 12 lb. per square inch and developing 48 h.p. at 2,250 r.p.m., the exhaust being throttled to give a back pressure of 13·5 lb. per square inch, and the second being "snort cruise power" with the engine unsupercharged and developing 12 h.p. at 1,125 r.p.m. with a back pressure of 8 lb. per square inch.

Tests run at full power revealed no unusual features and, apart from minor modifications, were carried out successfully. The next test, said Mr. Millington, was to be 1,000 hours of mixed running—made up of repeated cycles of 4 hours full power followed by 40 hours of snort. However, after 650 hours had been run, such severe wear had occurred that the test had had to be abandoned. The maximum wear measured was 0·016 in. on the diameter (the radial measurement technique had not been developed at that time) and the chromium plating had been penetrated over considerable areas.

Ten tests, each of 100 hours duration, were then run with the object of determining the cause of this excessive wear. Mr. Millington described how, by varying the running conditions, it was tentatively decided that severe wear occurred when fuels containing sulphur were used while the liner walls were kept at temperatures below 130 deg. C. The next five tests were devoted to examining the theory that chromium plating was not satisfactory when running at high temperatures. However, no wear was detected even when the surface was held at 240 deg. C.

EFFECT OF FUEL SULPHUR CONTENT

The next series of tests described by the author were intended to check the effects of different fuels, but anomalous results were obtained. Investigation of engine conditions showed that various changes had occurred, including a change in the lubricating-oil additive and the hardness of the piston rings, both changes being unknown to the experimenters. Tests therefore had to be repeated to determine the effect of these. It was found that a fuel low in sulphur gave negligable wear and that hardened piston rings gave less wear than "as cast" ones.

The conclusions drawn by Mr. Millington from the 42 tests carried out on the engine (representing about 4,800 hours running) were that chromium plating was perfectly satisfactory when the running temperature was high, but that serious wear occurred when running with the walls below 130 deg. C. if a fuel containing only 0·8 to 1·0 per cent. of sulphur were used. This wear could be substantially reduced by using hardened and tempered piston rings (440 Brinell). Calculations and a study of available literature suggested that the wear was initially caused by the condensation of sulphuric acid on the cylinder walls, followed by abrasion caused by corrosion debris becoming imbedded in the soft rings. Chromium plating itself was quite satisfactory up to 240 deg. C. and wear could be reduced by using hardened and tempered rings.

STRESS CONCENTRATION FACTORS*

RELATING THEORETICAL AND PRACTICAL FACTORS IN FATIGUE LOADING

By R. B. Heywood, PH.D., M.I.MECH.E.

Theoretical stress concentration factors such as those obtained by the photoelastician cannot in general be applied directly to strength values in practice, because of differences that exist between the hypothetical material assumed by theory and the crystalline aggregate used by the engineer. Some of the causes for this discrepancy are discussed, and comments are made on methods of relating theoretical and practical factors. The paper refers particularly to parts subjected to fatigue loading.

The application of mathematical and experimental methods of stress analysis has produced a wealth of information on values of stress concentration factors for widely differing designs. The information has been correlated in the literature, and the designer is usually able to ascertain the value of the factor for the particular case in which he is interested. The maximum stress is then obtained by multiplying the value of the factor by the nominal stress. This knowledge of maximum stress can be related to the mechanical properties of the material, and so an estimate of strength can be made. In general, this estimate is not a reliable one, because the idealised homogeneous and elastic material assumed in arriving at the theoretical stress concentration factor does not accurately represent the structural material actually used in practice. This causes observed strength values of notched parts to be equal to or greater than is indicated by a direct application of theoretical stress concentration factors. If appreciably greater, then clearly a conservative and uneconomic design is produced when full allowance for stress concentration is made. However, a complete lack of consideration of the effect of stress concentrations can have, and indeed has had, a disastrous effect on the estimation of strength in certain instances. What is required is the use of some relationship connecting theoretical and effective factors, which not only produces realistic results, but is also of a sufficiently simple form for it to be employed in the design office without difficulty.

A number of relationships have been suggested, and in this paper an assessment of their qualities is made. The more complicated relationships, such as those requiring two or more notch sensitivity constants of the material, will not be considered, as they are not likely to be used in practice, even though they may have a more satisfactory theoretical basis for their derivation. For ductile materials, theoretical stress concentration factors have not been applied successfully to estimations of static strength of notched parts. Plastic flow largely nullifies the effect of the stress concentration, so making this case of but little importance. One can merely ascertain the nominal stress at which yielding commences at the stress concentration, but this knowledge is of little practical value. For brittle materials, however, the theoretical solution is of considerable value in indicating strength, especially if allowance be made for size effect. Perhaps the most important application of theoretical results is the estimation of strength of parts subjected to fatigue, and it is particularly some aspects of this problem which will be considered.

THEORIES OF FAILURE INVOLVING THREE PRINCIPAL STRESSES

For unnotched parts, failure may not depend wholly on the maximum stress, but on some combination of the three principal stresses or strains acting at a point. Many theories of failure based on combined stress have been proposed[1], and in particular the maximum shear energy or Mises-Hencky criterion of failure has often given good agreement with experiment for ductile materials. According to the Mises-Hencky criterion, failure occurs when the stress f exceeds a critical value in the relationship

$$f = \frac{1}{\sqrt{2}} \sqrt{(P - Q)^2 + (Q - R)^2 + (R - P)^2},$$

where P, Q and R are the principal stresses. However, when applying these theories to the determination of strength of notched parts, difficulties arise which show that solutions may still be inaccurate. For example the pointed V groove with zero root radius possesses an infinite stress concentration factor (s.c.f.), a value which would be still obtained if a combined stress theory were applied, in contrast to the finite value found in practice. This effect persists with V-grooves having a small base radius, when discrepancies between effective and theoretical factors would be finite but large.

Yen and Dolan[2], in reviewing the subject of notch sensitivity, have pointed out that s.c.f's. based on the shear energy criterion give only slightly lower values than those based simply on the maximum stress. For a grooved bar in tension and for a Poisson's ratio of 0·3, it may be shown that the effective factor ranges from 89 to 100 per cent. of the theoretical factor for different sizes of groove. Most other theories of failure give percentages greater than 89, and so these laws can only partly account for the much larger discrepancies that are often obtained between theory and practice. A plate containing a free hole is an example where combined stress laws are of no use. In whatever manner the part be loaded, only the circumferential principal stress has any magnitude at the critical corners of the hole, and therefore all theories of combined stress must make the effective factor equal in value to the theoretical factor. Such a behaviour is not usually obtained in practice. A further difficulty in accepting a combined stress theory as the only cause of discrepancy is that no differentiation in the notch sensitivities of different materials can be made—all materials must behave similarly. Thus the application of theories of failure based on combined stress can modify values of the theoretical s.c.f. to give slightly closer estimates of strength, but nevertheless this accounts for only part of the correction required.

Influence of Plastic Flow.—In the static testing of notched ductile members the influence of plastic flow in modifying stress distributions is so great that a knowledge of theoretical stress distributions is of little value in indicating strength. Plastic flow or inelastic strain may also occur in fatigue, but to a much lesser extent. In fatigue tests on plain specimens in bending, Forrest and Tapsell,[3] at the National Physical Laboratory, have shown that inelastic strain may cause a redistribution of stress during each cycle, so that the maximum stress becomes less than the calculated elastic value. This gives one reason why the fatigue strength in bending is usually greater than in axial loading.

A similar behaviour would be expected with notched parts in fatigue, causing the maximum stress to be less than the elastic value; see Fig. 1. Inelastic strain is produced in both plain and notched specimens, but for direct loading stress redistribution can only occur in the latter case, so giving an effective factor lower in value than the theoretical s.c.f. Redistribution of stress is probably independent of size, so that the effective stress concentration factor (strength reduction factor) can be expressed simply as some function of the theoretical factor.

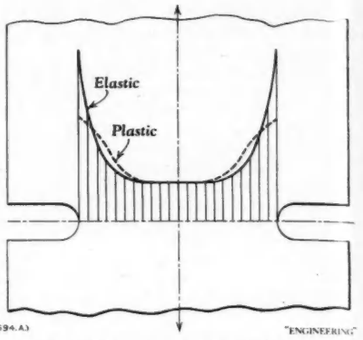

Fig. 1 Redistribution of stress due to plastic flow.

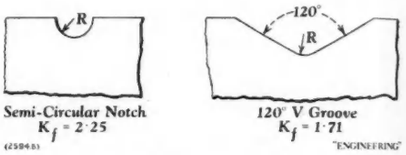

Fig. 2 Effect of flank-angle term in Neuber's formula.

The notch sensitivity index, to be discussed later, was originally devised by Thum to assess behaviour under these conditions.

The importance of inelastic strain on notched fatigue strength has not yet been fully assessed: it will obviously have a greater influence with the more ductile materials, with increase in temperature of test, and with reduction in cycles to failure. However, inelastic strain probably has very little influence on the fatigue limit of notched specimens which are made in a medium or high-tensile strength steel or in a high strength aluminium alloy and tested at room temperature, so that theoretical factors do not need to be modified to take account of this effect.

Size Effect.—Size effect is known to have a marked influence on the strength of notched parts, particularly in fatigue. The behaviour is such that a part containing a very large notch possesses small stress gradients, and consequently material in the vicinity of maximum stress behaves as in a plain bar, and so produces the full reduction in strength as indicated by the theoretical s.c.f.* At the other extreme an exceedingly small notch could be of a size comparable with that of inherent imperfections within the engineering material, and then the notch would produce no further weakening effect than is already present, so making the effective s.c.f. of unit value. Thus the effective s.c.f. ranges in value from unity for the very small notch to that of the theoretical s.c.f. for the large notch, but never exceeds this latter value. Intermediate values must necessarily be obtained for notches of intermediate size. Size effect can be appreciated most readily with cast iron, where large flaws due to the presence of graphite flakes normally make the material insensitive to notches. If, however, the size of notch is large compared with the size of graphite flakes, even this material would become notch sensitive. As size effect and the associated stress gradient has such a strong influence on the application of theoretical results to practice, it is suggested that when investigations are made to determine values of the theoretical s.c.f., consideration be given also to the measurement of the stress gradients and the second (and third) principal stresses at the point of maximum stress. Ultimately this would enable a more rational assessment of the different types of notches to be made.

Notch Sensitivity Index.—The above simple analysis on size effect demonstrates that it is not advisable to use the so-called notch sensiti-

* Paper presented for discussion at the International Colloquium on Photoelasticity and Photoplasticity held in Brussels, July 29 to 31, 1954. Here published for the first time.

* The assumption of a linear stress-strain curve is involved here.

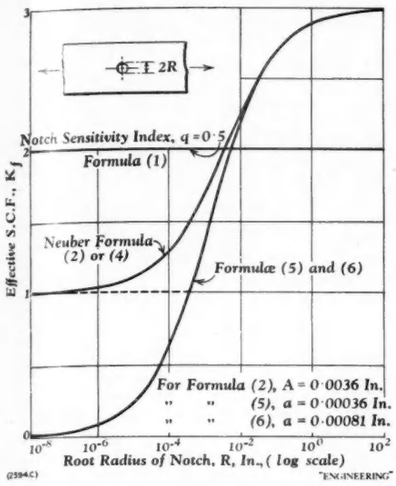
2R
Notch Sensitivity Index, q = 0·5
Formula (1)
Neuber Formula (2) or (4)
Formulæ (5) and (6)
For Formula (2), A = 0·0036 In.
" " (5), a = 0·00036 In.
" " (6), a = 0·00081 In.
Effective S.C.F., K_f
Root Radius of Notch, R, In., (log scale)
(2594-C)
"ENGINEERING"

Fig. 3 Notch size effect of transverse holes in specimens as assessed by various formulae.

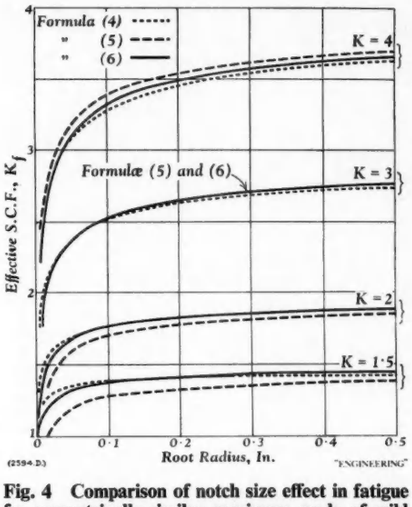

Fig. 4 Comparison of notch size effect in fatigue for geometrically-similar specimens made of mild steel.

vity index q, defined as

$$q = \frac{K_f - 1}{K - 1}, \quad . \quad . \quad . \quad (1)$$

or

$$K_f = 1 + q\,(K - 1),$$

where

K_f = effective s.c.f. or strength reduction factor

$$= \frac{\text{stress causing failure in unnotched part}}{\text{nominal stress causing failure in notched part}}$$

and

K = theoretical s.c.f.

$$= \frac{\text{maximum stress in notch}}{\text{nominal stress based on minimum notch section}}$$

The terms on the right-hand side of this second formula are independent of size, and so no allowance is made for this effect on values of the factor K_f. Size effect could only be allowed for by making the value of the index q vary with size, but this would lead to confusion in the comparison of notch sensitivities of materials and in the application of theoretical results to practice. Thus at best, this well-known formula can only take account of the effect of plastic flow in modifying stress distributions.

NEUBER'S FORMULA

The difference between theoretical and practical factors has been explained by Neuber[4] on the grounds that the average stress acting over a small elementary block of material is significant, and this led him to suggest the empirical relationship

$$K_f = 1 + \frac{K - 1}{1 + \frac{\pi}{\pi - \omega}\sqrt{\frac{A}{R}}} = \frac{K + \frac{\pi}{\pi - \omega}\sqrt{\frac{A}{R}}}{1 + \frac{\pi}{\pi - \omega}\sqrt{\frac{A}{R}}}, \quad . \quad . \quad . \quad (2)$$

where

A = a material constant, having dimensions of length, and representing half the width of the elementary block,

R = root radius of notch,

ω = included angle of notch in radians, for notches made in the form of a V groove $\left(\text{flank angle} = \frac{\omega}{2}\right)$.

This formula satisfactorily takes into account size effect by incorporating a critical dimension of the notch, namely, the root radius, R. With progressive reduction in radius the effective factor becomes a smaller fraction of the theoretical factor, and so is in accordance with observed trends. In this formula the effect of flank angle is assessed twice, first by a dependency of the value of the theoretical factor on flank angle, and secondly by the term $\frac{\pi}{\pi - \omega}$. Both reduce the value of the effective factor with increase in flank angle. In order to verify this double influence of flank angle, accurate values of the theoretical factor for different flank angles and very accurate fatigue test data would be required. As far as is known precise information on both points is not available, and hence there is some doubt whether allowance for flank angle has been correctly represented in the formula.

The effect of flank angle correction can be appreciated in a particular case if a semi-circular notch is compared with a 120-deg. V-groove, both of which have the same value of the root radius of R = 0·01 in., and the same theoretical factor of K = 3 (obtained for the 120-deg. notch by using suitable other dimensions such as notch depth), see Fig. 2. By assuming a typical value of Neuber's material constant of A = 0·0036 in. (as given by Kuhn and Hardrath[5] for a 100,000 lb. per square inch steel tested in fatigue), then by formula (2) the value of the effective factor K_f is 2·25 for the semi-circular notch but only 1·71 for the 120-deg. notch. This difference in values is greater than would reasonably be expected, since the equality in theoretical factors and root radii must produce approximately equal stress gradients at the points of equal maximum stress. The practical factor for the semi-circular notch is not affected by flank angle, since the angle is zero, and so it follows that the factor for the V-groove must be low.

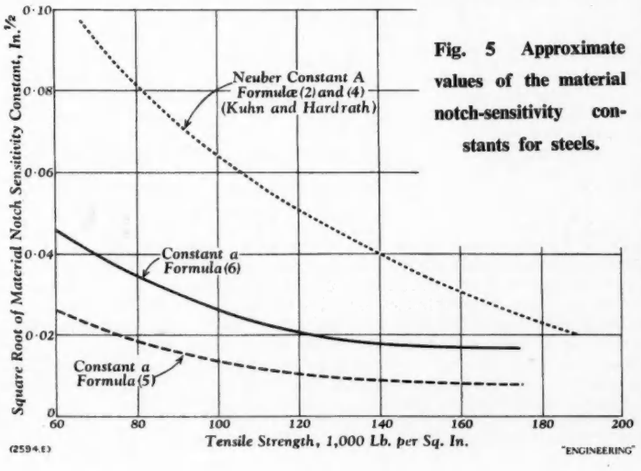

Fig. 5 Approximate values of the material notch-sensitivity constants for steels.

This comparison can be extended to cover any one of a series of U-grooves with a corresponding one of a series of V-grooves, so that for each pair the values of the quantities K, R and A are the same. In each case differences are obtained in the practical factors which can only be attributed to low values for the V-groove due to the influence of the flank-angle term.

If formula (2) is re-written in the form

$$K_f = \frac{K\sqrt{\frac{R}{A}} + \frac{\pi}{\pi - \omega}}{\sqrt{\frac{R}{A}} + \frac{\pi}{\pi - \omega}}, \quad . \quad (3)$$

then in the above comparison the effect of flank-angle correction is apparent from the second terms by varying the angle ω. Practical factors are reduced by increasing the angle, which for constancy in the values of the quantities K, R and A does not appear reasonable.

This difficulty associated with correction for flank angle in Neuber's formula may be overcome by assuming that the theoretical factor refers to a particular type of notch such, as a parallel-sided or a hyperbolic groove, having a depth and root radius equal to the V-notch under consideration. The theoretical factor would not then vary with flank angle, and so duplication in the allowance for flank angle would be avoided. This is possibly Neuber's own interpretation. Alternatively the theoretical factor may be given its normal interpretation for V-notches, and the flank-angle term could then be omitted, so giving the relationship

$$K_f = \frac{K + \sqrt{\frac{A}{R}}}{1 + \sqrt{\frac{A}{R}}}. \quad . \quad . \quad . \quad (4)$$

This formula was given by Neuber in a preliminary stage of development of formula (2), and appears to be the more satisfactory alternative, as no restrictions are placed on the interpretation of the theoretical factor.

Neuber's formula (2), and also formula (4), possesses the further difficulty that the trend in size effect does not appear to be in accordance with what would be expected for notches of extremely small size. Engineering materials possess flaws and irregularities in their structure, and if an exceedingly small geometrical notch is introduced which is even smaller than the inherent flaws, then no reduction in strength can be expected. The formula does indicate a reduction in strength in this case, demonstrating that it is not applicable to notches of this order of size.

The effect can be demonstrated by considering geometrically-similar notched specimens having the same value of the theoretical factor for all sizes. In formula (2) it can be seen that however small the notch (as represented by the dimension R), the value of the effective factor must always be greater than unity—only in the limit is unity obtained—so producing some reduction in strength. An example is shown in Fig. 3 for a circular transverse hole, assuming a theoretical factor of 3 and a typical value of the material constant of A = 0·0036 in. A hole of only 10^{-7} in. radius reduces the strength by as much as 1 per cent., even though inherent flaws of the order of at least 100 times this size are present. Although the difficulty is revealed by examining this hypothetical notch of exceedingly small size, the effect nevertheless per-

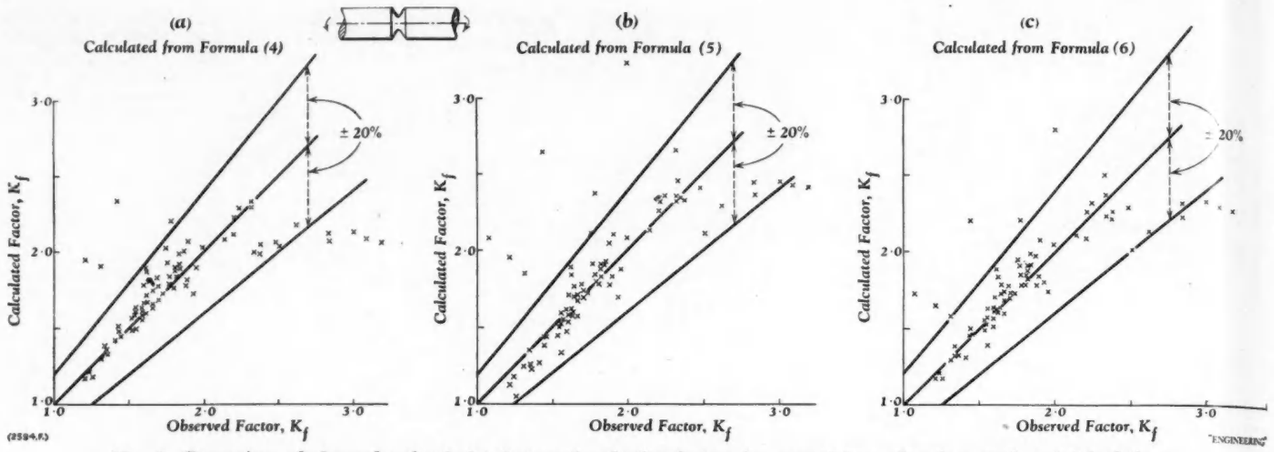

Fig. 6 Comparison of observed and calculated strength reduction factors for grooved bars of various steels tested in fatigue.

sists for larger notches in the range of practical sizes. The greatest discrepancy probably occurs when notch size is of the same order as that of inherent flaws, for then no reduction in strength due to the notch would be expected.

Thus Neuber's formula appears to give too high a value of the effective s.c.f. for notches of a size comparable with that of inherent flaws, and so should not be used in such cases. As the formula may also give low values on account of flank-angle correction, it may happen that the two errors cancel out in particular instances, giving apparent agreement. The modified formula (4) eliminates the difficulty associated with flank angle, and gives reasonable trends in size effect for all notches including V-notches, except those of very small size. It thus appears that this formula is of greater practical value.

PROPOSED FORMULAE

An alternative solution can be found by regarding the material as containing a number of stress concentrations due to its heterogeneous nature. Not only the crystals themselves with their anisotropic properties, dislocations and boundary effects, but also inclusions, cavities and surface discontinuities in the material produce irregularities in the micro-stress distribution. These stress concentrations can be regarded as originating from equivalent flaws of characteristic size distributed throughout the material. An analysis of the interacting effect of equivalent flaws with geometrical stress concentrations that are introduced leads to a simple empirical material notch formula, which has been suggested previously by the author,[6] namely

$$K_f = \frac{K}{1 + 2\sqrt{\frac{a}{R}}}, \quad . \quad . \quad (5)$$

where a = material notch length, corresponding to the length of the equivalent inherent flaw.

This formula satisfies the limiting conditions, and although based on different concepts from Neuber's, it possesses similar characteristics as to size effect. Incidentally, by following the analysis and assumptions used by Neuber in deriving his formula, one can equally well arrive at formula (5), if correction for flank angle is omitted, for the reasons discussed above. Formula (5) overcomes the difficulty associated with the small notch, as shown in Fig. 3. As size of notch is reduced, so a point is reached where the value of the factor K_f becomes unity, when the notch has the same weakening effect as the inherent flaws. For even smaller sizes the value of K_f drops below unity, signifying that the notch under consideration produces less weakening effect than that due to inherent flaws of larger size. The material as a whole should therefore have an effective factor of unit value.

When the value of the theoretical factor approaches unity, the base radius of notch must be large compared with the other dimensions, such as notch depth. With large values of the radius, the value of the effective factor must approach unity in formula (5). If, however, the notch depth is extremely small and the base radius is of typical proportions, values of the effective factor may be very slightly below unity (this happens when notch depth is less than the material notch length.) As effective factors greater than unity should be obtained for this case, formula (5) can be elaborated to

$$K_f = \frac{K}{1 + 2\sqrt{\frac{a}{R}}\left(\frac{K-1}{K}\right)} \quad . \quad . \quad (6)$$

This ensures that when the theoretical factor has the value of unity, the effective factor must also have the value of unity, and thus the formula gives realistic trends for notches of extremely small depth.

A comparison between the three formulae (4), (5) and (6) is made in Fig. 4 for a series of geometrically-similar specimens of different size. For Neuber's simplified formula (4), the value of the material constant A is assumed to be 0·01 in., this being appropriate to fatigue tests on a mild steel with strong influence of size. With formula (5) a material notch length of $a = 0{\cdot}00085$ in. is assumed, and with formula (6), $a = 0{\cdot}0019$ in. The comparison shows that general trends are very similar for all three formulae over most of the range of size.

In applying Neuber's formula to fatigue results, Kuhn and Hardrath have demonstrated that the value of the material constant A is approximately dependent upon the tensile strength of the steels used. The values that were suggested are given in Fig. 5, together with corresponding values of the material notch length for formula (5) and also for formula (6). By applying these values to a series of circumferentially grooved specimens tested in bending that has been given by Kuhn and Hardrath, a comparison between observed and calculated effective factors may be obtained, as shown in Fig. 6. The graphs demonstrate that all three formulae give the same order of accuracy, with the calculated value usually being within 20 per cent. of the observed value for the very wide range of tests covered. Discrepancies could be due to the fact that notch sensitivity is not dependent simply on tensile strength, but it is more probable that the very high standards required in testing technique have not always been achieved in this series of results, which were obtained from many different sources.

By considering in similar manner the data provided by Kuhn and Hardrath for other types of notches, such as shouldered shafts and bars with transverse holes, it is found that all three formulae give approximately the same agreement with experiment, with formula (6) being very slightly better than formula (5), and this in turn is very slightly better than formula (4). The average discrepancy is of the order of 10 per cent. For design purposes it is considered that all three formulae are capable of assessing size effect to a degree of accuracy far greater than is likely to be required in practice, and so any one formula could be recommended. While there are some grounds for favouring the use of formula (6), there is a need for accurate fatigue data covering a wide variety of different types and sizes of notch for a few representative materials, so that the limitations and accuracy of formulae may be assessed.

CONCLUSIONS

Theoretical stress concentration factors for notched parts may be applied to practical strength values for fatigue loading, and for static loading of brittle parts. The application to the static loading of ductile parts is confined to estimations of local yielding in notches. The following three factors may be involved in the application.

(1) A combined stress criterion of failure applied to the stress conditions existing at the point of maximum stress. This produces a modified stress concentration factor which may be lower in value than the theoretical factor.

(2) A redistribution of stress due to inelastic behaviour, which may occur even under fatigue conditions. The magnitude of the effect depends on the material and conditions of test.

(3) A size effect in notched parts, which is associated with the stress gradients at the point of maximum stress. The magnitude of the effect depends on the size of notch, the material and the conditions of test.

For most design problems involving the determination of the fatigue limit of notched parts it is sufficient to allow only for size effect as given in item (3) above, when behaviour can be predicted by use of a simple formula involving a characteristic notch sensitivity constant.

The author wishes to express his appreciation to the Chief Scientist, Ministry of Supply, for permission to present this paper.

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THE USE OF DATA ANALYSIS IN DESIGN

RECENT INFORMATION CONCERNING CARGO LINERS

Compromise necessarily plays an important part in most engineering designs; many different requirements, often conflicting, must be reconciled, and numerous unrelated factors taken into consideration. This is especially true in the case of a structural and mechanical complex like an aircraft or a ship. In dealing with design problems of this kind therefore, the designer needs access to all relevant information, which must moreover be arranged in such a way that it can be readily interpreted; tabulation of performance figures, and graphical and statistical analysis are typical methods of approach. Economic and technical factors in the design and operation of cargo liners were treated in this way in a paper which formed the basis of the 27th Thomas Lowe Gray Lecture delivered by Cdr. (E) L. Baker, D.S.C., R.N. (ret.)* on Friday, January 21, to the Institution of Mechanical Engineers. In his lecture, which was entitled " Some Factors in the Selection of Machinery for Cargo Liners," Cdr. Baker brought up-to-date the available data concerning these vessels.

He first outlined the object of maintaining a cargo-liner fleet and continued with a short discussion on the speed of cargo liners, and of the factors influencing liner schedules. After dealing with the design of a new ship and its analysis by the naval architects, he considered in detail the power/weight ratio of machinery, the effect of type of propulsion on the Admiralty coefficient, and the mean Admiralty coefficient for ships in service. The method of selecting machinery for a particular design was outlined, and machinery required for port use was briefly covered. Progress in the use of the Diesel engine for marine propulsion and its attendant problem of cylinder-liner wear were discussed and also developments in steam propulsion. Cdr. Baker examined in addition the costs involved in running a ship, including those for stores, repairs and fuel, and concluded the lecture by analysing a design and showing how the choice of ship machinery is affected by fuel considerations.

ADMIRALTY COEFFICIENT AND PROPULSION

The approach adopted by Cdr. Baker in his survey is well illustrated by his treatment of propulsion and related subjects. The Admiralty coefficient, which serves in general as a guide to the efficiency of a hull, although not a true constant, is of considerable value in this form of investigation, and is defined by the expression:

$$C = \frac{\Delta^{\frac{2}{3}} V^3}{\text{effective horse-power}},$$

where C is the Admiralty coefficient, Δ the displacement of the ship in tons and V its speed in knots through the water. Fig. 1 is a graphical comparison of results obtained from three ships, and shows one form of relationship involving Admiralty coefficient. It is plotted on a time basis in terms of date at the end of successive voyages with Admiralty coefficient as ordinates.

Vessel (*a*) is a single-screw 18·5-knot steamship of the " P " class, with a design Admiralty coefficient of 305, and (*b*) and (*c*) are two single-screw " A "-class motorships with service speeds in excess of 15·5 knots, and design Admiralty coefficients in both cases of 325. It is worthy of note that, whereas 25 years ago a coefficient of 290 was considered adequate for a new ship, coefficients as high as 350 are obtained consistently to-day. The two motor ships have identical hulls but one (*c*) is propelled by a 6,800-brake horse-power eight-cylinder double-acting two-stroke Diesel engine running at 116 r.p.m. and the other by a 7,000-brake horse-power seven-cylinder single-acting two-stroke Diesel engine running at 107 r.p.m.

Several inferences may be drawn from these graphs. Although the hulls of the two motor vessels are identical, the values of Admiralty coefficient differ widely in the two cases and it follows that the form of propulsion must have a considerable influence on this quantity. Possibly 2 per cent. of the difference is due to better propulsive efficiency obtained with the slower-running propeller, but the remainder must result from other causes. The second conclusion is that monsoon weather noticeably affects the value of the coefficient, since the graph undulations are of a seasonal nature; it is evident, moreover, that the steamship is less subject to weather variations than the motorships.

Perhaps the most important factors governing the choice of ship machinery are concerned with economic operation, such as weight, space occupied and fuel consumption; to these might be added as second-order considerations capital and maintenance costs. In Fig. 2 is reproduced a nomogram employed by Cdr. Baker to indicate the relationship between these quantities. It provides a method of evaluating daily operating costs; the dotted line represents a worked example for a particular case.

FUEL COST AND CONSUMPTION

Table I lists the principal forms of power unit used for propulsion and gives in addition the associated rates of fuel consumption. It should be noted, however, that the gas turbine has at present a serious disadvantage in that for long-life operation it requires a distillate fuel. In order to assess these figures from an economic viewpoint it is necessary to know the comparative costs of the fuels employed.

TABLE I.—*Sources of Power for Main Propulsion*

(*a*) Diesel Engines

Type	Fuel rate, lb. per b.h.p. per hr.
1. Direct drive, on boiler oil	0·395
2. Direct drive, on Diesel oil	0·385
3. Geared drive, on boiler oil	0·43—0·45
4. Geared drive, on Diesel oil	0·42—0·44
5. Diesel-electric, on Diesel oil or gas oil	0·5 (approx.)

(*b*) Steam Turbines

Type	Fuel rate, lb. per s.h.p. per hr.
6. Turbo-electric, on boiler oil	0·55—0·65
7. Geared turbine, on boiler oil	0·5—0·6 (depending on cycle and steam conditions)

(*c*) Gas Turbine

Type	Estimated fuel rate lb. per s.h.p. per hr.
8. On distillate fuel	0·5—0·7

The average cost of marine Diesel fuel is about half as much again as boiler fuel and it follows therefore that a Diesel installation using Diesel fuel can only compete with steam turbines when the aggregate weight of the machinery, water and fuel for a given voyage and the space occupied by the machinery are equal to or less than those for the corresponding steam plant. The power at which this occurs is rather less than 7,000 shaft horse-power with direct drive machinery, and with geared drive when using Diesel engines rotating at less than about 750 r.p.m. Above this value the Diesel engine must burn boiler fuel, thereby achieving once more a gain in economy over the steamship.

The method by which this figure is determined illustrates the manner in which data is interpreted. Estimates of fuel consumption, relative fuel costs, machinery weight and size, and power output are collected, tabled and recorded graphically, and, so clarified, provide the required optimum value.

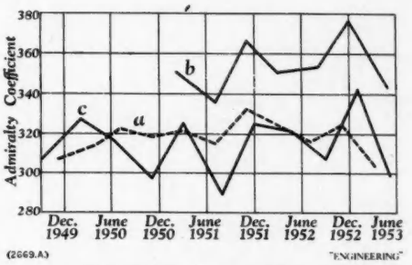

Fig. 1 Graph comparing Admiralty coefficients of three ships. (a) is a single-screw steamship, (b) and (c) are single-screw motor vessels with identical hulls; (b) has single-acting and (c) double-acting engines.

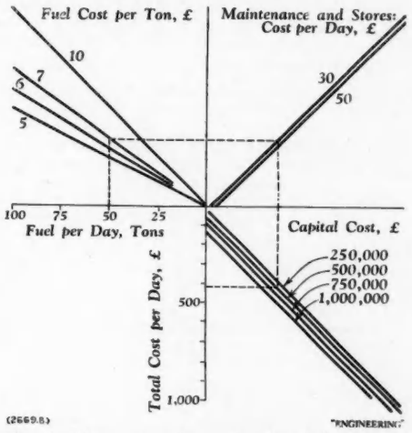

Fig. 2 Nomogram for evaluating daily cost of operating a vessel. The principal expenditure is on fuel.

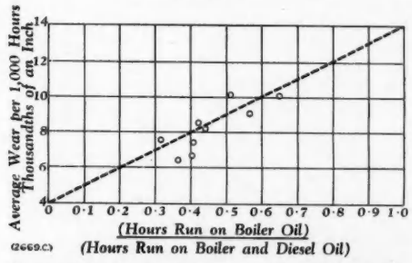

Fig. 3 Graph showing wear of cylinder liners in terms of fuel-oil quality. Figures for liners from nine ships were treated statistically to give the line indicated.

STEAM AND DIESEL DEVELOPMENT

Tables II and III give figures indicating the development of Diesel and steam-turbine machinery during recent years and enable a comparison to be made over the final period. In particular, it can be seen that considerable reductions in weight, and improvements in thermal efficiency have been achieved in Diesel-ship design, and that some classes of steamship suffer from the disadvantages of wide variations in fuel consumption for nominally identical ships (the ranges of values of fuel rate and thermal efficiency for ships completed in 1949 refer to series of exactly similar vessels).

Recent progress in marine Diesel-engine practice includes the introduction in 1945 of

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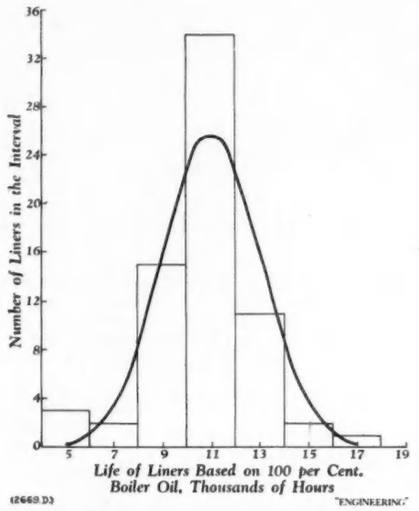

Fig. 4 Histogram based on the wear observed on 68 cylinder liners from double-acting two-stroke Diesel engines.

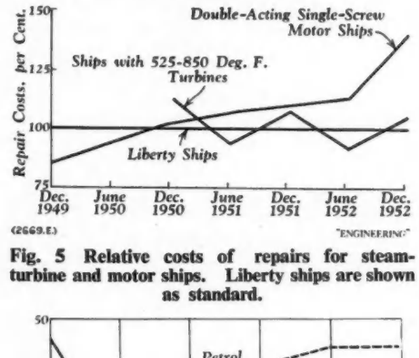

Fig. 5 Relative costs of repairs for steam-turbine and motor ships. Liberty ships are shown as standard.

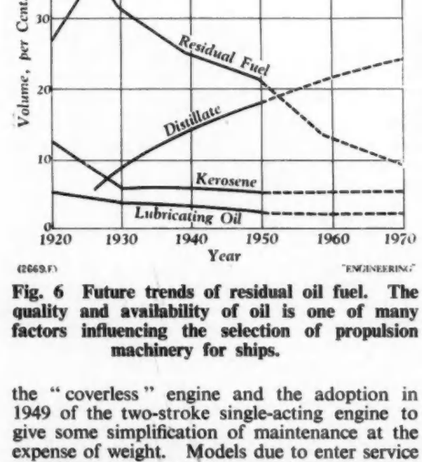

Fig. 6 Future trends of residual oil fuel. The quality and availability of oil is one of many factors influencing the selection of propulsion machinery for ships.

the "coverless" engine and the adoption in 1949 of the two-stroke single-acting engine to give some simplification of maintenance at the expense of weight. Models due to enter service in 1955 are exhaust-turbine supercharged versions of the 1949 design. It is also of interest that in approximately 30 years the power developed by Diesel machinery installed in an engine room of given size has more than trebled.

A further trend in marine Diesel-engine design is towards standardisation, a tendency which also applies to ship design in general. For example, the bores and strokes specified for main engines by one company have been uniform since 1949, and the Diesel generators employed in motor ships were of one pattern from 1947 to 1954 when a new standard was adopted.

TABLE II.—*Progress of Diesel-Driven Ships*

Year of completion	Machinery	Motor ships, maximum continuous shaft power, s.h.p.	Machinery weight, lb. per b.h.p.	Fuel rate, lb. per s.h.p. for all purposes	Efficiency, per cent.
1929	T.S. Diesel S.A.4S. supercharged	8,000	450	0·40	34·3
1936	S.S. Diesel D.A.2S.	3,100	408	0·42	32·7
1938	T.S. Diesel D.A.2S.	11,800	364	0·40	34·3
1943	S.S. Diesel D.A.2S.	8,000	351		
1945	S.S. Diesel D.A.2S.	6,800	363	0·39	35·2
1947	S.S. Diesel D.A.2S.	6,800	370		
1950	S.S. Diesel S.A.2S.	7,000	439	0·385	35·7
1955	Sketch design S.A.2S. supercharged	8,000	327	0·38(?)	36·1(?)

T.S. — Twin screw. S.A. — Single acting.
S.S. — Single screw. D.A. — Double acting.
4S. — Four stroke. 2S. — Two stroke.

observed, approximately one third of the profit in using boiler fuel is lost in extra replacement of liners and rings.

ECONOMIC FACTORS

As has been pointed out the ultimate consideration on which cargo-liner design must be based is an economic one and to provide a foundation for calculating ship specifications, Cdr. Baker gave in his lecture the following equations:

Profit = (gross income) − (expenditure).

Gross income = (freight paid for outward and homeward voyages) + (passenger fares).

Expenditure = (cost of fuel for round voyage) + (cargo-handling charges, etc.) + (agent's fees) + (port and canal dues) + (crew wages and victualling) + (coast of repairs to ship) + (capital charges and depreciation) + (cost of stores, spare gear, etc.) + (surveyor's fees) + (dry-docking cost) + (share of overheads).

Although these factors are almost entirely non-technical, they must, nevertheless all be reflected in the ship design selected for a given service.

TABLE III.—PROGRESS OF STEAMSHIPS

Year of completion	Steam conditions	Maximum continuous power, b.h.p.	Length of engine room, feet	Machinery weight, lb. per s.h.p.	Fuel rate, lb. per s.h.p. for all purposes	Thermal efficiency, per cent.
1949	S.S. turbine, 450/750 deg. F. ..	6,800	58	250	0·61—0·65	22·5—21·1
1949	S.S. turbine, 525/850 deg. F. ..	15,000	63	209	0·56—0·61	24·5—22·5
1952	S.S. turbine, 625/950 deg. F. ..	8,000	51	243	0·53	25·9
—	Sketch design, S.S. turbine, 625/950 deg. F.	11,500	54	207	0·52 (?)	26·4 (?)

TABLE IV.—*Analysis of Voyage Costs for Motor and Steam-Turbine Vessels*

Item	"P" and "H" class steam turbines, per cent.	"A" class motor ship, per cent.
Fuel at full speed ..	26·7	17·0
Fuel in port	4·2	2·6
Wages	11·5	15·9
Victualling	3·3	4·7
Repairs	9·8	11·6
Stores	2·9	4·1
Cargo expenses ..	41·6	44·1
Total	100	100

STATISTICAL ANALYSIS

Statistical methods are sometimes useful in the preparation of data analyses and Cdr. Baker has adopted this approach in his study of wear on cylinder liners. Cylinder-liner wear is the key to the economics of burning boiler oil in Diesel engines; a simple four-stroke engine shows the same figures for liner wear, irrespective of the fuel employed, but the double-acting two-stroke engine has a greatly increased wear rate when running on boiler oil, despite the use of detergent cylinder oils.

To avoid personal discrepancies, measurements of liner wear per 1,000 hours were made by one investigator, and when sufficient data had been collected, statistical techniques were applied to a sample of 83 liners from nine ships. Fifteen liners were removed from service owing to cracks, but for the remainder, the method of least squares gave the equation:

$$y = 10x + 4,$$

where y is average wear per thousand hours, and x is the ratio of time on boiler oil to time on Diesel oil. Fig. 3 represents this equation graphically and shows the points corresponding to average values of liner wear for the nine ships.

The maximum wear permitted on cylinder liners is 160 thousandths of an inch and to determine the running time on boiler fuel alone which would give this degree of wear, the actual running hours can be corrected with the aid of the equation. In this way the histogram shown in Fig. 4 was obtained.

From this it may be seen that no extraneous factor, such as the type of piston ring or grade of cylinder lubricating oil, has a major influence on wear within the limits of current practice. It is worth noting that with the rate of wear

Table IV, for example, shows the cost of various items as a percentage of the total expenditure for voyages carried out in 1953, and in listing the corresponding proportions for steam-turbine and motor vessels, illustrates the way in which factors of this kind might influence the choice of propulsion machinery for particular duties. Fig. 5, which gives relative repair costs for the two types of vessel (Liberty ships are used as a standard at 100 per cent.), provides a further guide to the selection of plant. Another factor which must play an important part in the choice of machinery for future ships is the quality and availability of different kinds of fuel, and Fig. 6 shows future residual oil fuel trends on a volume basis.

These are only a few of the considerations involved in selecting machinery for ships, and it is evident that in dealing with data in such large quantities systematic treatment is necessary. In his lecture Cdr. Baker not only provided a comprehensive range of information on this subject but also illustrated the technique to be adopted in its analysis.

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SUMMER SCHOOL OF WELDING

The British Welding Research Association, 29 Park-crescent, London, W.1, are organising a fifth Summer School of Welding, to be held at Ashorne Hill, near Leamington Spa, Warwickshire, from Monday, June 27, until Saturday, July 2.

The School takes for its basic theme "Welding Developments in British Industry" and has been devised to cover various aspects in logical sequence during the course. As in previous years lectures of general interest will be given in the morning and lectures of more specialised interest in the afternoon. To meet particular requirements, students will be divided into four groups, namely, group A—pressure vessels; group B—transport; group C—shipbuilding; and group D—specialised welding techniques.

It is proposed to organise an exhibition at the school to illustrate the latest welding methods and recent developments in these processes.

The school is open to all and, it is considered, should be of value to managerial staff, engineers, designers, drawing-office staff, technicians, etc.

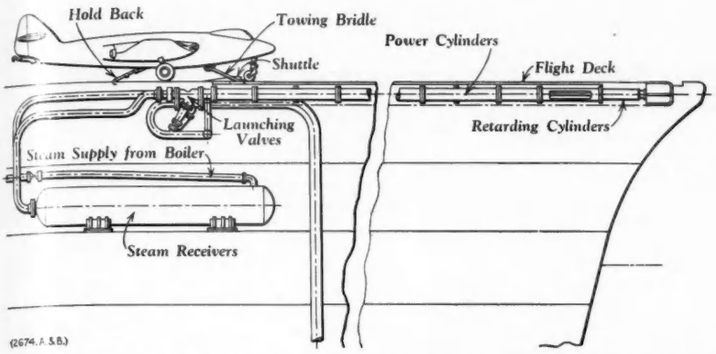


Fig. 1 In the steam catapult, the shuttle which tows the aircraft is propelled along its track in the deck by two pistons, directly connected to it, which slide in two cylinders side-by-side under the deck extending the whole length of the track.

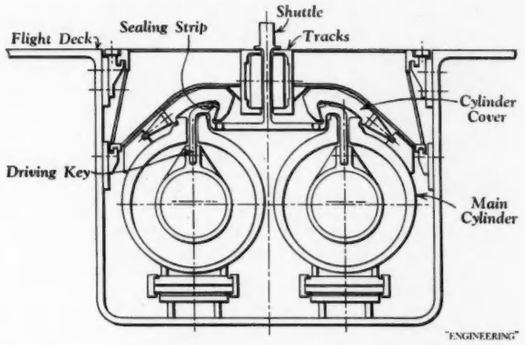


Fig. 2 Cross-section through the catapult. The shuttle comprises an inverted T; dogs at each edge of the flange engage in corresponding dogs in the driving key attached to each piston, allowing a slight movement of the track relative to the cylinders.

STEAM LAUNCHING CATAPULTS

STANDARD EQUIPMENT FOR AIRCRAFT CARRIERS

The first operational installation of the new steam catapults which are being produced and developed for the Admiralty by Brown Brothers and Company, Limited, Edinburgh, for launching the fast and large aircraft of the future from aircraft carriers, will be in H.M.S. Ark Royal, the fleet carrier expected to be completed by Cammell Laird and Company, Limited, Birkenhead, early this year. Similar catapults are also being constructed for H.M.S. Hermes and H.M.A.S. Majestic, both being built by Vickers-Armstrongs, Limited, Barrow; for H.M.C.S. Bonaventure, under construction by Harland and Wolff, Limited, Belfast, and for H.M.S. Victorious, now undergoing extensive modernisation at H.M. Dockyard, Portsmouth. It is the intention to replace with steam catapults the existing hydro-pneumatic catapults in all other operational carriers of the Royal Navy, as production and service commitments permit.

We give below a description of the steam catapult, prepared by Mr. C. C. Mitchell, O.B.E., B.Sc., M.I.Mech.E., director of Brown Brothers and Company, Limited.

The first slotted-cylinder catapult for launching aircraft using steam from the ship's boilers acting directly on the catapult itself, was installed for trials in H.M.S. Perseus during 1950, and trials continued throughout 1950 and 1951. The success attending these led to the adoption of what are becoming known as the "steam catapults" now being installed in H.M. ships.

In catapults prior to the steam catapult, the power to launch the aircraft was generated in a hydro-pneumatic unit below the deck. The accelerating force was transmitted to the aircraft by flexible steel-wire ropes passing round pulleys; a small trolley running in a track sunk flush in the flight deck was attached to the ends of these ropes, and the towing bridle which pulled the aircraft along the deck was hooked to the trolley.

With increase in the weight of the aircraft and the requirement for higher launching speeds, larger and heavier power units were required and correspondingly heavier ropes and pulleys needed. It was evident that there would be a limit of magnitude and weight beyond which they would become too great for installation in any ordinary ship.

SHUTTLE DIRECTLY PROPELLED BY PISTONS

In the steam catapult a completely different principle is employed in that the shuttle, or trolley, to which the aircraft is connected by its towing bridle, is propelled along its track in the deck by two pistons which are directly connected to it, and which slide in two steam cylinders placed side by side under the deck and extending the whole length of the track.

Steam pressure acts directly on these pistons and propels them along the cylinders; the comparatively light pistons and the shuttle are the only moving parts of the catapult. Fig. 1 illustrates a typical layout in the ship and shows the power cylinders housed under the deck and the steam receivers in which steam from the boilers is stored ready for the launch.

Fig. 1 also illustrates an aircraft secured by its towing bridle to the shuttle and held back against the thrust of its own engines, which must be run up to full power prior to the commencement of a launch, by a "holdback" which is hooked in a suitable fitting on the deck. When the aircraft is ready to be launched, with its engines running at full power, the launching valves are opened, admitting steam from the receivers to the after side of the main pistons in the power cylinders. The force on the pistons generated by this steam breaks a calibrated weak link in the holdback and accelerates the pistons, shuttle and aircraft to the required speed along the deck.

Fig. 2 shows a cross section through the catapult and illustrates how the two power cylinders are installed side by side in the trough formed in the flight deck. This trough is closed by two movable tracks or portions of deck which carry the channel-shaped rails in which the shuttle runs upon its rollers. The body of the shuttle is in the shape of an inverted T of which the upper part projects through a slot between the two channel rails above the deck and forms the hook to which the towing bridle is attached. The flange of the T on the underside is furnished at each edge with dogs which engage in corresponding dogs in the driving key attached to the piston. The two pistons and the shuttle are constrained to move axially, but have freedom relative to each other so that slight movement of the track or cylinders is possible. The dogs are provided with ample bearing surfaces.

CYLINDER GAP SEALED BY STEEL STRIP

Each piston assembly consists of a main piston, piston distance piece, guide piston, retarding ram, driving key and driving iron (Fig. 3). The main cylinder consists of a combination of three components, namely, the cylinder itself, the cylinder cover and the sealing strip. The cylinder cover is of a hook shape and at one end engages a rounded surface formed on the cylinder in such a way as to permit rotational or hinge freedom relative to the cylinder, while at the other end of the hook a gap is left between the cylinder cover and the top of the cylinder bar. Into this gap is fitted the sealing strip, a strip of steel of rectangular section, which is bent up and down over an arc of large radius by the piston as it moves along the cylinder.

Successive sections through the piston and cylinder are shown in Fig. 3. Section (*a*) shows a section through the driving key with the sealing strip lifted up by the driving key and passing over it so that it leaves the gap between the cylinder cover and cylinder open for the emergence of the tongue of the driving key which carries the dogs engaging with the shuttle. As the piston moves forward, the sealing strip, which does not move axially in the cylinder, is guided downwards by the slope of the upper surface of the driving key and the under surface of the driving iron, which guides the strip right down into its position in the gap between the cylinder cover and the cylinder bar, as shown in Section (*b*). Section (*c*) shows the main steam piston with the component known as the sealing block mounted upon it,

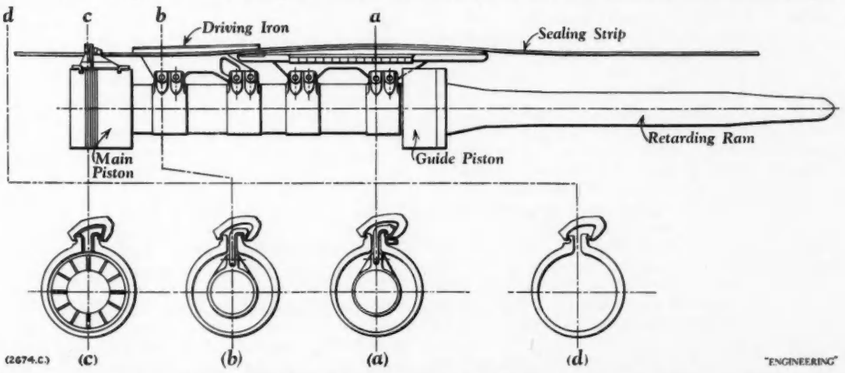


Fig. 3 The sealing strip is lifted by the passage of the driving key to allow the movement of the driving dogs. As the piston advances, the driving key and driving iron guide the sealing strip down to seal the gap.

whose function is to seal the space in the cylinder cover and in the gap between the cylinder bars. As the piston moves forward it leaves the strip in the position shown in section (*d*). The steam pressure is acting immediately behind the main piston and the sealing block, and the effect of the steam pressure on the cylinder is to make it tend to open at the gap, but this tendency is resisted by the combination of the cylinder cover and the sealing strip, the latter acting as a strut transversely between the cylinder bar and the cylinder cover. In this way the cylinder under pressure becomes a stable structure and the compression loads on the sides of the sealing strip due to its structural function create an effective seal against the escape of internal pressure and form what is virtually a closed cylinder in the wake of the piston.

It will be noted that the combination of cylinder cover and sealing strip restore the strength which was lost to the cylinder by cutting the gap in the cylinder wall, and that no external bracing or other component is required outside the cylinder. This is one of the features which made the adoption of a catapult of this type possible in a ship, where an externally braced cylinder would absorb an unacceptable amount of space and weight. This design of cylinder and piston assembly is the subject of a patent by Brown Brothers and Company, Limited, and Mr. C. C. Mitchell.

RETARDING CYLINDER

The length of the accelerating stroke, and therefore of the assembled cylinder, is only limited by the length of the ship, but it is necessary to stop the piston assemblies and shuttle when they have reached the end of their available stroke. For this purpose two steel cylinders are arranged co-axially with the power cylinders, bearing at their closed forward ends on a heavy structural member built into the ship's hull. These cylinders are open at their after end and kept full of water by pumping a supply through a series of nozzles in a ring at the open end of the cylinder. The nozzles are inclined axially and tangentially so that the water emerging from them follows a helical path down the bore of the cylinder. When this flow of water reaches the closed end of the cylinder, its rotation is arrested by vanes on the face of the end plug and the water thereafter flows axially along the centre of the cylinder, and spills out through the centre of the vortex formed by the jets. By this means, it is possible to maintain the cylinders full of water which is free of air bubbles. This method of filling and retaining the cylinder full is a development of a suggestion made by Mr. J. R. C. Waterston of Brown Brothers and Company, Limited, and is the subject of a patent.

The forward end of each piston assembly has fixed to it a retarding ram tapering from forward to aft, the largest diameter being slightly less than that of the bore of the choke ring fitted in the mouth of the retarding cylinder. As the piston assemblies, shuttle and aircraft are propelled forward by the steam pressure, the point of the retarding ram enters the open end of the retarding cylinder, and the water which it displaces from the cylinder is forced to pass at high velocity through the annulus formed between the bore of the choke ring and the surface of the retarding ram. Since the velocity of the water through this annulus is very high, the pressure in the water within the retarding cylinder is raised thereby and creates a resistance to the forward movement of the ram sufficient to bring it to rest within its own length. The energy of the water expelled through the annulus is further assisted in stopping the piston assembly by impinging on a curved annular surface or "bucket" formed at the base of the retarding ram. This form of retardation has been used by the Admiralty in catapults manufactured before and during the war.

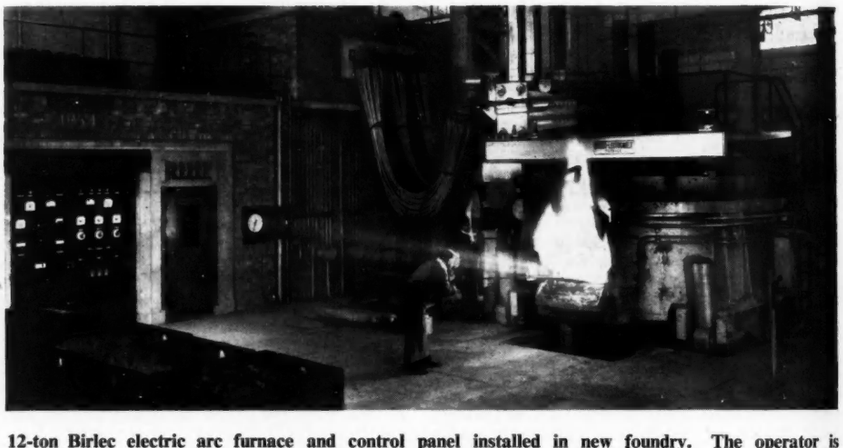
For the operation and control of the various valves and ancillary equipment, a separate hydraulic system is employed using pressure generated by a turbo-driven hydraulic pump. This hydraulic power is also used for retracting the pistons and shuttle from the forward end of the catapult after a launch to the after end ready for loading on another aircraft, and this part of the equipment consists of a small hydraulic cylinder which, through a multiple reeving, propels an engaging hook back and forward along the track.

The controls of the catapult are centralised in a control console situated in the machinery compartment where the control worker operates all the functions of the catapult, the necessary indications and interlocks being provided electrically. A secondary control position is provided at the edge of the flight deck where a second control worker operates a push button which fires the catapult, after it has been made ready at the main control console.

The design and development of this type of catapult has been carried out for the Admiralty by Brown Brothers and Company, Limited, Edinburgh, under the instructions and supervision of the Department of the Engineer-in-Chief of the Fleet. Valuable assistance in the development has been given by the Admiralty Engineering Laboratory, West Drayton, and the Naval Construction Research Establishment, Rosyth, who carried out photo-elastic, strain gauge, and fatigue tests and analysis on cylinder and cylinder cover sections, and by the British Welding Research Association, Cambridge, who subjected a complete cylinder section to a pulsating-pressure fatigue test. Prior to the installation of the prototype in H.M.S. Perseus, a shortened version of the catapult was installed at Shoeburyness where extensive tests on the retarding gear were carried out by the Armament Research Establishment.

The prototype was installed in H.M.S. Perseus, which was commissioned specially for this purpose, by H.M. Dockyard, Rosyth, and deadload trials using dummies instead of aircraft were carried out at Rosyth by the ship, with the assistance of the Dockyard.

Subsequent to these trials, H.M.S. Perseus (Captain H. A. Traill, C.B.E., R.N., and later Captain R. G. Poole, R.N.) went to Belfast for flying trials using aircraft, and then to Philadelphia, U.S.A., where flying trials were continued. On her return from America, the catapult was removed during the summer of 1952.



12-ton Birlec electric arc furnace and control panel installed in new foundry. The operator is sampling the melt through the furnace door.

EXTENSIONS TO ROLL-MAKING FOUNDRY

INSTALLATION OF ELECTRIC ARC FURNACE

A programme of expansion and development to be achieved in two stages was undertaken in 1948 by R. B. Tennent, Limited, Coatbridge, Lanarkshire, and has now been completed. This company, which has extensive facilities for the casting, heat treatment and machining of large components, has specialised in the manufacture of rolls for rolling mills since the last century, and it is to increase productive capacity in this field that the new premises have been built. One building recently finished is a roll-making foundry in which has been installed a Birlec 12-ton "Lectromelt" electric-arc furnace, with advantages which include enhanced control of alloy composition.

The expansion involved the erection of additional premises for research, heat treatment, machining, moulding and casting, and by 1950, two buildings had been finished. This was followed by the installation of oil-fired heat treatment furnaces, heavy-duty lathes and ancillary equipment, thus completing the first phase. The second phase of the expansion programme was started in 1950 and ended this year. It included the erection of the new foundry, which houses moulding, drying, melting casting and annealing equipment and is connected with an earlier foundry by an electric transfer car. Of special note is the Birlec furnace which was installed in 1954 and is now in full operation.

The furnace, which was constructed by Birlec, Limited, Tyburn-road, Erdington, Birmingham, 24, has a diameter of 12 ft. and is made of heavy-gauge steel plates lined with suitable refractory material. A top stiffening bezel ring, which is water cooled, is provided to prevent distortion under heat. For slagging, oxygen lancing, fettling and other operations there is a refractory-lined door let into the furnace side. The pouring spout, which is also lined with refractory material, is attached to reinforcements on the shell.

The roof refractories are supported on a water-cooled channel-section ring which is suspended at four points on two structural-steel beams. This arrangement facilitates removal and replacement, and simplifies the aligning of electrode ports and electrodes. The roof structure has an eye attachment in which a vertical hydraulic ram engages to lift the roof clear of the furnace for top-charging purposes.

After the roof is raised clear of the furnace body it is swung horizontally through an angle

of nearly 75 deg. to expose the hearth. Loading can then be performed by lowering a drop-bottom bucket into the shell. These operations are effected by an interlocked mechanism to ensure that they take place in the correct sequence. The furnace is tilted by a pair of rams; oil pressure for the rams and for the roof-raising mechanism is generated in a self-contained electrically driven plant.

Power for operating the furnace is obtained from the public mains on the three-phase system at 11 kV through a metalclad switch supplied by A. Reyrolle and Company, Limited, Hebburn-on-Tyne. This switch controls the supply to a 4,000-kVA transformer made by the Electric Construction Company, Limited, Bushbury Works, Wolverhampton.

ARRANGEMENT OF ELECTRODES

The three 10-in. diameter electrodes are secured in water-cooled copper clamps and project vertically through the furnace roof. The clamps, which are operated by a remotely controlled pneumatic mechanism, are mounted on the ends of horizontal arms which also carry the electrical and water connections. The horizontal arms are connected to vertical masts by cross-heads, which in turn are suspended from flexible steel cables connected to separate winches.

The winches are installed below the furnace floor and are provided with drums over which the cables pass to terminate in counterweights. Each winch is driven through gearing from a direct-current motor, the field of which is permanently excited at constant voltage, and the speed and direction of which depend on the magnitude and polarity of the output voltage of an Amplidyne constructed by the British Thomson-Houston Company, Limited, Rugby. All the controls and metering equipment for the furnace are situated on a board on the wall of the transformer substation.

The illustration opposite shows an operator sampling the melt through the furnace door; it also shows the control panel and the manner in which the furnace is installed in the new foundry.

LOW-FRICTION FLUID SEALS

THE SOLUTION OF HYDRAULIC-RAM SEALING PROBLEMS

To provide a hydraulic seal suitable for use in circumstances where a high sealing efficiency must be combined with a minimum frictional resistance to the axial motion of moving parts, James Walker and Company, Limited, of Woking, Surrey, produce the Lion "Twinset" packing shown in Fig. 1. This packing is claimed by its makers to be virtually "drop-tight," and to offer little resistance to the operation of, for example, a hydraulic ram. Consisting basically of a U-ring, it can be adapted for use with water, oil and other fluid media, and can withstand a wide range of pressures. For cases in which it is inconvenient or impossible to compensate for wear by gland adjustment a spring-loaded header (Fig. 2) has been introduced as a refinement to the standard design.

Perhaps the most common application of gland packings requiring high sealing efficiency and low frictional resistance is the press ram which is designed to descend under gravity alone. The qualities demanded of the packing are the same whether the press is of the upstroking gravity-return, or downstroking prefilling pattern.

OIL AS PRESSURE MEDIUM

In recent years the growing use of oil as a pressure medium has increased the difficulty of the problem, since the consequences of allowing oil to escape are, owing to fire risk, expense and considerations of hygiene, more serious than those that arise when the fluid employed is water. Nevertheless, whether the medium is water or oil, leakage and high friction losses both entail loss of power input and, in the case of those forms of hydraulic press previously mentioned, loss of production due to unnecessarily slow press operation.

Particularly affected by these considerations is the plastics moulding press. Such presses often embody comparatively light main rams and operate on cycles calling for the highest possible speed of ram descent. On machines of this kind, the packing must offer the minimum frictional resistance while the unloaded ram is descending, and yet provide a near perfect seal under a pressure range of, say, zero to 4,500 lb. per square inch.

A further quality required of seals used for this type of application is the ability to sustain low pressures for long periods. The seals of downstroking rams, for example, may be subjected for considerable lengths of time to pressures lower than 5 lb. per square inch, and these are known to be at least as difficult to seal as pressures in the region of 2,000 lb. per square inch. If a packing is to be at the same time both virtually frictionless and capable of operating in the conditions described, it must be of a very flexible nature so that the reaction between the lips of the packing and the ram is nearly proportional to the applied pressure.

MATERIALS SELECTED FOR SERVICE

With these requirements in mind James Walker and Company developed the Lion Twinset packing. It comprises (Fig. 1) a shallow stuffing-box packing designed primarily for axially moving rams or shafts, where the pressure does not exceed 2 tons per square inch. It can also be used for some rotary applications, provided that the peripheral speed is very low.

The sealing member is an endless U-ring made from a rubber- or synthetic rubber-proofed fabric or from a solid rubber compound, the nature of which is dependent on service conditions. The lips of the U-ring are tapered (as indicated by chain-dotted lines in the drawings) to give a slight interference in order that there may be an initial seal even under low pressure. The fabric version is constructed in such a way that, although the lips exhibit an appreciable degree of flexibility, the strength of the seal is preserved.

A header, or spreader ring, is incorporated, and is normally composed of hard plastic material (SRP). It is grooved and drilled in order to promote speedy and even distribution of the pressure medium in the tongue-shaped cavity of the U-ring. The functions of the header are firstly to locate the U-ring, and secondly to maintain positive contact between lips and housing under low pressure, thus augmenting the sealing action of the tapered lips. All components of the seal can be made of various materials, and the unit is thus suitable for use with most hydraulic media over a wide range of pressures and temperatures.

Because the sealing action of this packing is automatic in that the lips respond to the application of pressure, it must not be subjected to heavy compression, for this would jeopardise satisfactory reaction and cause undue friction; the resulting excessive wear would eventually lead to the collapse of the U-ring. It is recommended that a very slight compression be applied to the packing and that this compression should be controlled by the use of spacers between the underside of the gland and the cylinder face in the manner illustrated in Fig. 1.

The Twinset packing can also be employed as a piston seal, but for double-acting piston heads the sets must be housed independently.

SPRING-LOADED HEADER

The spring-loaded header represented in Fig. 2 has been introduced as a modification of the standard design to cater for applications in which gland adjustment to allow for wear is inconvenient or impossible. It may also be used in circumstances where it is necessary to safeguard against excess compression.

As shown in the drawing, spring loading is achieved by the provision of a number of spring assemblies located in the header by a method which prevents their becoming detached during operation. Without any alteration to the housing, standard Twinset packings can be replaced by packings fitted with spring-loaded headers; both initial design and conversion are thereby simplified.

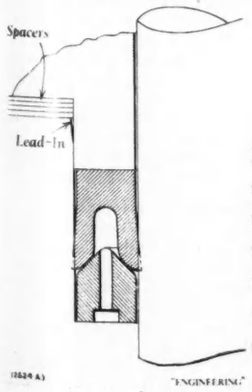


Fig. 1 The "Twinset" gland is designed to minimise friction on axially moving shafts and withstands pressures up to 2 tons per square inch.

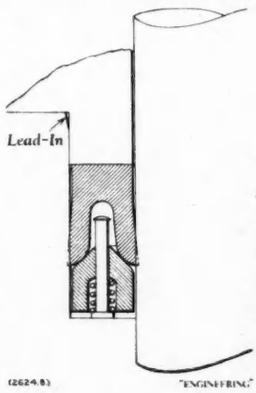


Fig. 2 For applications in which it is inconvenient to compensate for wear by gland adjustment a spring-loaded header can be used.

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CAR PARKING METER

One method that has been suggested for the relief of London's traffic congestion is to regiment the parking of cars by the use of parking meters. The meters would allow cars to stay at a parking station for a given time, after which the driver would have to pay more money or move his car. Many will disapprove heartily of the proposal to use parking meters, but it might do something to help to unravel the tangle of traffic congestion. One type of parking meter has been produced by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. It is designed to keep maintenance and attendance costs to the minimum; a coin is inserted and a knob is turned, and sufficient energy is then stored in a spring to operate the meter for the pre-selected parking time. The Metrovick meter can be provided with standard scales of 0–4, 0–2 or 0–1 hours; the 0–4 hours meter is designed to give two hours parking time for one sixpence and four hours for two sixpences or one shilling. To change the parking period necessitates only a change of dial and a change to the timing mechanism, which is effected by removing the price-change unit and substituting another.

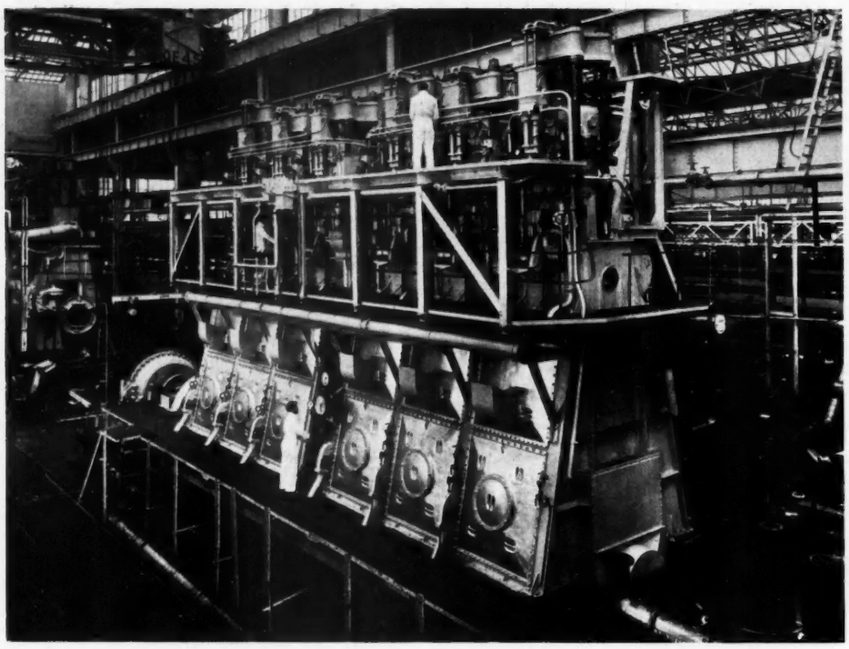


Fig. 1 On the test-bed at Belfast—Harland and Wolff's new 8,000-b.h.p. single-acting opposed-piston Diesel engine which is supercharged by exhaust-gas turbo-blowers.

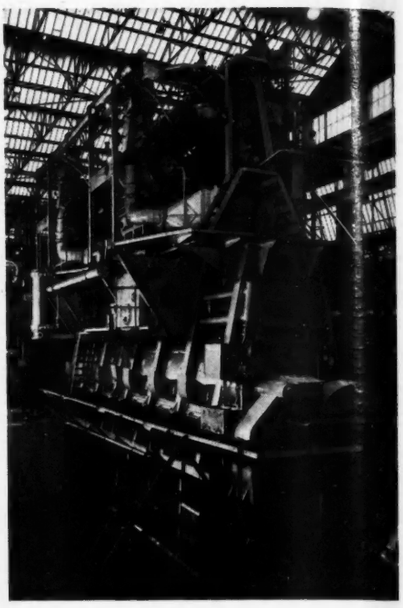


Fig. 2 The two Napier turbo-blowers can be seen in this illustration.

8,000-B.H.P. TWO-STROKE DIESEL ENGINE WITH EXHAUST-TURBINE SUPERCHARGING

During the past few weeks at Belfast, test-bed trials have been run of a single-acting two-stroke Diesel engine in which supercharging is by turbo-blowers driven by the exhaust gases of the engine. Harland and Wolff, Limited, the builders, state that the continuous service power is increased by 30 to 35 per cent. compared with normal induction. Full advantage is taken of the exhaust pulse from each cylinder: the volume of the exhaust pipe between the cylinder and the turbine is carefully chosen in order to obtain the maximum pulse energy by using the gases as nearly as practicable at the pressure and temperature of discharge from the cylinder. In addition, the fall in exhaust-manifold pressure after each pulse allows adequate scavenge air to pass through the cylinder, thus removing the residual exhaust gases and reducing the thermal stresses by cooling the piston and combustion space.

The arrangement is shown in simplified form in Fig. 4, applied to the six-cylinder Harland and Wolff engine. Two turbo-blowers are mounted on the back of the engine, and each is driven independently by the exhaust from three adjacent cylinders. The air delivered from the two compressors, however, is fed to a common induction manifold, from which it is delivered to the cylinders. It will be seen that the chain-driven Roots displacement-type scavenge-air blowers, which have always been characteristic of Harland and Wolff two-stroke engine, have been discarded. The engine is, indeed, the first single-acting two-stroke engine with piston-controlled exhaust ports to be turbo pressure-charged without the assistance of mechanically-driven scavenge pumps.

For driving the turbo-blowers when the Diesel engine is running at too low a speed for the exhaust gases to provide sufficient power, an electric motor is fitted to each blower. The motor cuts in and out automatically, as described later. This automatic motor arrangement has been provided at the request of the owners of the engine, Alfred Holt, Limited, but the builders would normally provide a small independently-driven air compressor for use under low-speed conditions.

A Serck cooler is fitted between each blower and the induction manifold (Fig. 4). This is necessary because the rise in temperature of the air as it passes through the compressor would otherwise prevent the increase in weight of charge from being proportional to the increase in pressure.

RANGE OF SIZES

The design of the new engine, apart from the turbo-charging arrangements, is generally similar to that of Harland and Wolff's normal-induction engine, which is a two-stroke crosshead-type single-acting opposed-piston engine. This engine was described in ENGINEERING, vol. 169, page 641 (1950), and the general arrangement drawings given at that time can be compared with those reproduced in Fig. 3 here. It has been extensively applied to many kinds of vessel, including large tankers, refrigerated cargo liners, cargo ships and tramps. It has also been installed, as a trunk engine, in cross-channel vessels and in power stations. As a propelling engine the two most popular cylinder sizes are: 750 mm. (29·53 in.) bore, 2,000 mm. (78·74 in.) combined stroke; and 620 mm. (24·41 in.) bore, 1,870 mm. (73·62 in.) combined stroke. With normal air induction, and with from four to eight cylinders, the range of power is thus 3,000 brake horse-power to 9,000 brake horse-power per screw, continuous sea ratings.

By pressure-charging, giving the 30 to 35 per cent. increase in power, the same cylinder sizes will cover the power range 4,000 brake horse-power to 14,000 brake horse-power from engines having four to nine cylinders. For the larger cylinder size, therefore, the output per cylinder is about 1,500 brake horse-power. This is equivalent to 9,000 brake horse-power for a six-cylinder unit of the type now on test, compared with 6,750 brake horse-power for a similar size engine with normal air induction. However, to comply with the owners' requirements for the first engine of the new type, the rating of this engine is very moderate; it will deliver 8,000 brake horse-power (British) or 8,100 brake horse-power (metric) at 112 r.p.m. The piston speed is 5·6 metres per second (1,100 ft. per minute), and the mean indicated pressure is 7 kg. per square centimetre (100 lb. per square inch). Other figures released so far are: fuel consumption 155 grammes per brake horse-power per hour (0·34 lb. per brake horse-power per hour); firing pressure 52 kg. per square centimetre (740 lb. per square inch); compression pressure 41 kg. per square centimetre (580 lb. per square inch); air scavenge pressure 4·5 lb. per square inch; blower speed 5,500 r.p.m.

The engine has been designed to run continuously at sea on heavy fuel oils of viscosities up to 3,500 seconds (Redwood No. 1). Such fuels have been successfully burned for years in normal induction engine sizes with the Harland and Wolff positive cam-operated standard fuel-injection system. For the engine on test, however, Wilson and Kyle gas-compression fuel pumps and valves are fitted, in accordance with Blue Funnel Line requirements.

The weight of the six-cylinder engine, complete with turbo-blowers, over the crank ends, is 480 tons—a saving of 110 tons compared with a normal-induction engine. The turbo-charged engine is 40 ft. 8 in. over the frames, compared with 48 ft. 6 in. for the equivalent non-pressure-charged engine, a saving of 7 ft. 10 in.

It will be clear from the foregoing that the way is now open for twin-screw ships of 24,000 s.h.p. aggregate continuous service power to be propelled by two eight-cylinder direct-coupled Diesel engines, and for ships of up to 14,000 s.h.p. to be propelled by a nine-cylinder single-screw unit.

TURBO-BLOWERS

The turbo-blowers were supplied by D. Napier and Son, Limited, London, W.3, with whom Harland and Wolff have a licence arrangement. The design is based on that of the Napier turbo-blowers which have been in use for several years on industrial, rail-traction and marine Diesel engines. These blowers are fully described, with drawings, performance data, etc., in publication No. 146 issued by D. Napier and

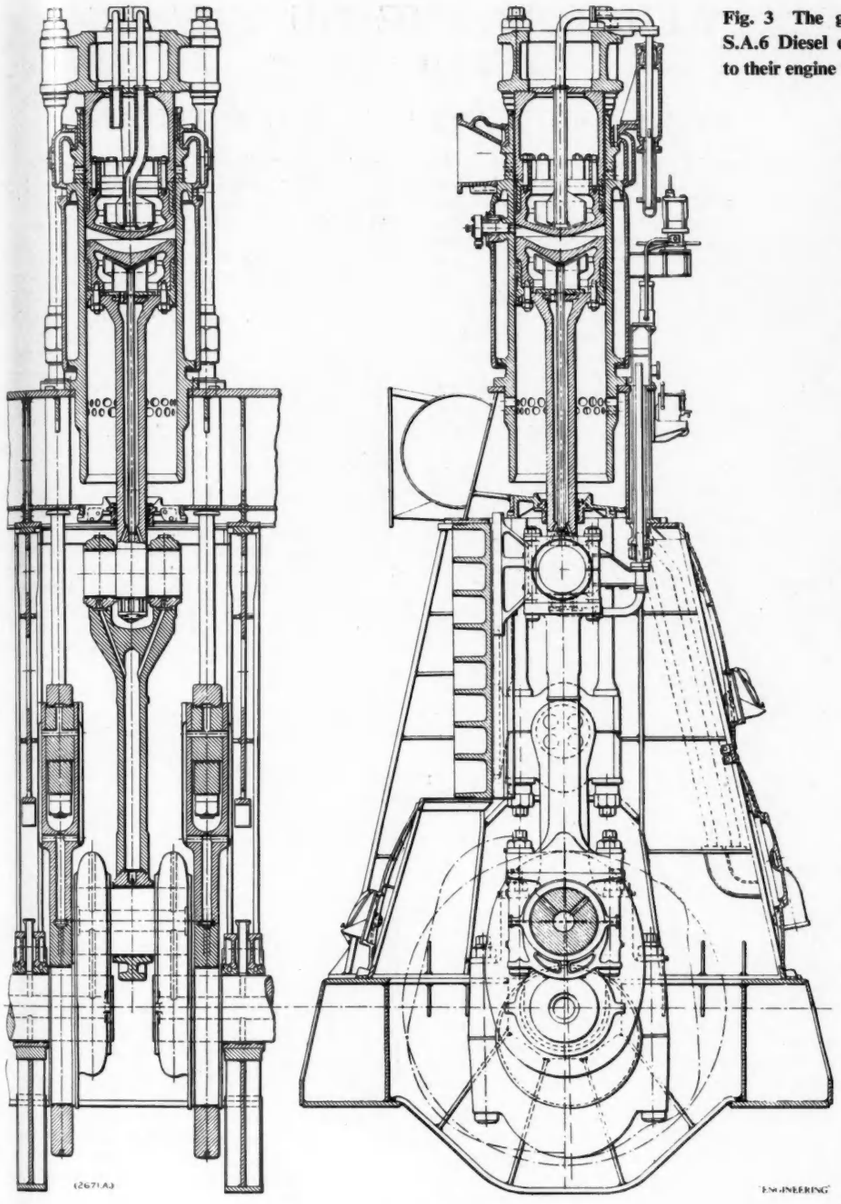


Fig. 3 The general arrangement of the Harland and Wolff S.A.6 Diesel engine is similar, except for the supercharging, to their engine with normal air induction introduced five years ago.

Son, Limited. The blowers used on the Harland and Wolff engine are type MS600.

The MS600 turbo-blower, which is shown in Fig. 5, consists of four casings bolted together to house a single-stage axial-flow turbine and a centrifugal air compressor, mounted on a common shaft. The turbine casings have internal water jackets that are connected to the engine cooling system. The rotor assembly is supported in plain sleeve-type bearings mounted in spherical housings which permit some universal movement in sockets in the casings, and also facilitate maintenance of the bearings, which can be removed without disturbing the casings. The bearings are pressure fed from an auxiliary-driven pump that delivers oil to connections on the end covers.

In the S.A.6 installation, the blowers are equipped with trunnion mountings in addition to the mounting brackets. These enable the blowers to be swung through 90 deg. from the normal position if required, so that during overhaul, components can be removed by a vertical lift. A combined air filter and silencer may be fitted in place of the compressor inlet casing; this provides ten filter panels that may be removed one at a time for cleaning while the turbo-blower is operating.

CONTROL MECHANISM

Under slow running conditions, when both the temperature and pressure of the exhaust gases from the engine are low, the energy released may be insufficient to maintain the turbo-blower output. This condition is aggravated during astern running when the air shortage due to the effect of the crank-angle phase difference on the astern port timing further diminishes the available exhaust energy. The blower is therefore fitted with a direct-current 10-h.p. motor that is automatically energised and engaged with the turbo-blower rotor shaft through an air-operated clutch below approximately 1,800 r.p.m. to ensure adequate output until the blower is self-supporting.

The blowers (and the blower driving motors when they are running) are pressure fed with lubricating oil from a self-contained system incorporating a dual-element filter and a cooler. The lubricating-oil pump and its driving motor are duplicated, and the two sets are so inter-

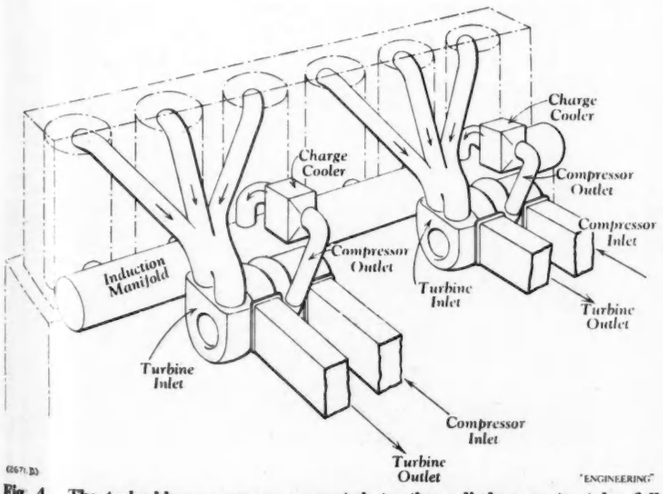
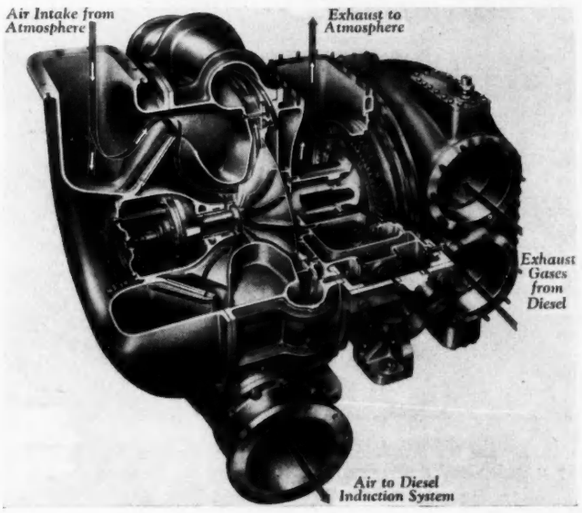


Fig. 4 The turbo-blowers are so connected to the cylinders as to take full advantage of the separate exhaust pulses in charging and scavenging.

Fig. 5 (below) Showing the principle of the Napier MS 600 turbo-blower, which increases the power of the Harland and Wolff Diesel engine by 30 to 35 per cent.



connected through Igranic switches that if the one in service fails the other is automatically brought into operation.

When the engine-room comes on "stand-by" one of the lubricating-oil pumps is started and set to automatic control, the supply passing to the turbo-blower, but not to the driving motors until they are started through their respective starter boxes. As each blower motor is started, contacts in the starter box simultaneously actuate two solenoid valves; one opens the lubricating circuit to the motor bearings and the other admits air to the clutch, so engaging the motor with the turbo-blower rotor shaft and driving it until the Diesel engine is started and its exhaust gases are sufficient to produce a speed in excess of 1,800 r.p.m. As this speed is achieved, the tacho-generator fitted on the compressor end of the turbo-blower generates enough voltage to operate the relay, and this cuts off the power supply to the motor and closes the solenoid valve in the air line, so disengaging the clutch. At the same time the solenoid valve in the lubricating-oil line shuts off the oil supply to the motor bearings without interrupting the supply to the turbo-blower bearings.

This condition prevails until the Diesel engine speed is reduced to the point at which the blower speed falls below 1,800 r.p.m., when the tacho-generator output fails to maintain the relay position and the motoring system is again brought into action.

The functioning of the system is monitored by signal lights which indicate that: (i) the blower motor(s) are energised; (ii) the Airflex clutch(es) are engaged; (iii) the lubricating-oil pump(s) are running; and (iv) the lubricating-oil pressure is satisfactory.

In addition to the automatic change-over switches interconnecting the duplicate lubricating-oil pumps, a flow switch is fitted in each of the blower/motor lubricating circuits as an extra safety precaution to shut off the appropriate blower motor if the oil flow is reduced below an acceptable level.

The principal dimensions, etc., of the Napier MS600 turbo-blower are: overall dimensions—length 92 in., width 66 in., height 70 in.; net dry weight 7,000 lb.; minimum oil pressure 40 lb. per square inch; operating air pressure 60 to 100 lb. per square inch; maximum turbine inlet temperature 1,200 deg. F. (650 deg. C.). Performance figures are given below.

—	Maximum Continuous	Maximum One-Hour Limit
Speed, r.p.m.	6,400	7,360
Pressure ratio (nominal) ..	1·5 : 1	1·7 : 1
Sea-level delivery pressure (gauge), lb. per sq. in. ..	7·35	10·3

WEIGHING THE OUTPUT OF A COLLIERY

AN AUTOMATIC WEIGHER AND TOTALISER

Coal is weighed at a colliery pithead for a number of reasons, and the use which is made of the figures obtained may vary according to local customs and agreements, but weighing is always necessary, and some form of weighing machine is to be found at every colliery. In the past, when outputs were smaller, a simple platform scale with rails to suit the colliery tubs and a steelyard-type weight indicator was all that was needed. As outputs increased, the need for greater speed in weighing was met by the use of a self-indicating scale, and a type was evolved which became the colliery standard. The machine was equipped with adjustable means for counterbalancing the tare weight of the pit tubs, so that only the net weight of the coal was shown on the weight-indicating chart. For a considerable time no change in design was necessary. The machine was fast enough in operation to suit the speed at which the tubs arrived at the surface, and where tubs of varying tare weight were used, the appropriate adjustment could be made on the machine by hand as required.

In recent years conditions have changed. As a result of increased mechanisation it is now possible for tubs to arrive at the pithead at such short intervals, consistently, and over as long a period as required, that manual recording of weight is becoming difficult. That this mechanisation will increase is obvious, and it will, in time, render the older type of weighing machine obsolete. There are two possible alternatives: continuous weighing by means of a machine incorporated in a belt conveyor; and automatic weighing and totalising of the coal contained in the tubs as they arrive at the surface. The former method, while it is perfectly satisfactory for recording total output, has certain disadvantages. In the first place, the belt conveyor and its associated weighing machine require a fairly large structure to accommodate them. This structure may or may not exist; if it does not, the cost of building it has to be considered. Secondly, it may be desirable to weigh the coal in the tubs as it arrives at the pithead, and before it is discharged by tipplers into the bulk flow to the coal-preparation plant. The second method of weighing has the advantage that little or no structural alteration is needed at the pithead.

NO WEIGHMAN REQUIRED

At Whitwick Colliery, Coalville, Leicestershire, which is in the East Midlands Division, Area No. 7, of the National Coal Board, an orthodox self-indicating weighing machine was used to ascertain the output of the pit. This machine has been replaced by an automatic weigher and totaliser, designed and built by Henry Pooley and Son, Limited, Birmingham, in co-operation with the National Coal Board's Area General Manager, Mr. W. Torrance, and Area Chief Engineer, Mr. F. Ashley. The new machine fits into the space formerly occupied by the old one and, working in conjunction with tub-arresting gear designed and made by the National Coal Board, weighs each tub individually and records the total weight and number of tubs without manual assistance (Fig. 1).

Whitwick Colliery produces 1,700 to 1,800 tons of coal a day from a depth of 290 yards. The coal is wound in double-deck cages, pneumatic decking gear being provided to enable the tubs to be handled at high speed. When winding is in progress, a 40-second cycle is operated, that is, a cage containing empty tubs is lowered to the bottom, the empty tubs are discharged and the full ones loaded, the cage is wound to the surface, the full tubs are pushed off by a fresh set of empties, and the cage starts its descent again, in a

Fig. 1 The Pooley automatic colliery tub weigher and totaliser fits into the space formerly occupied by an ordinary weighing machine.

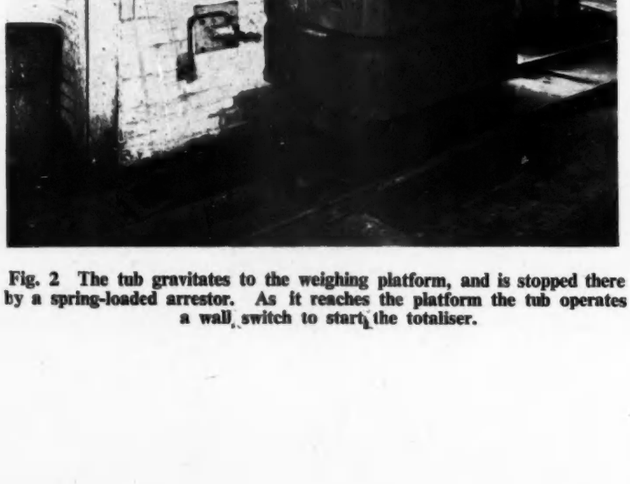


Fig. 2 The tub gravitates to the weighing platform, and is stopped there by a spring-loaded arrestor. As it reaches the platform the tub operates a wall switch to start the totaliser.

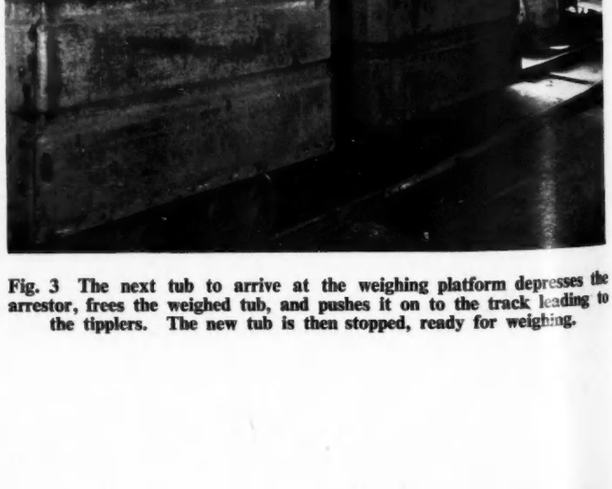


Fig. 3 The next tub to arrive at the weighing platform depresses the arrestor, frees the weighed tub, and pushes it on to the track leading to the tipplers. The new tub is then stopped, ready for weighing.

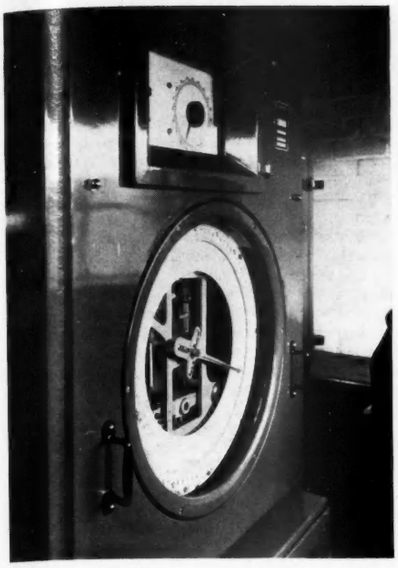


Fig. 4 The individual net weight of each load is indicated on a dial, and the total weight is shown on the totaliser.

total time of 40 seconds. About 3 tons of coal are raised at each wind.

The full tubs are discharged from the cage to a creeper, which raises them to the top of a gently-inclined track leading to the weighing machine, thence to the tipplers, and so back to the pithead. A tub-arrestor is provided to space the tubs on the creeper, and the speed of the latter is such that one tub is delivered to the weighing machine track every 18 seconds.

AUTOMATIC CONTROL OF TUB MOVEMENT

The weighing machine has a platform 5 ft. by 4 ft., with narrow-gauge flat-bottomed rails to suit the tubs. The platform is carried by a lever system of orthodox design, and is sunk flush with the floor. It is fixed close to a small weigh-office, the distance between the centre of the platform and the centre of the weighing and totalising mechanism in the office being 6 ft. Fixed in the centre of the rail track on the ingoing side of the weighing platform is the tub-arrestor, which stops each tub as it reaches the centre of the platform (Fig. 2).

The arrestor is a fabricated steel lever, anchored clear of the weighing platform, and projecting over it to end in a wide twin fork which engages the tub axle. The arrestor is spring-loaded to remain normally in the " up " position, and is so arranged that the part of the lever between the anchorage and the fork forms a ramp, which makes contact with the underside of the tub axle. The first tub to arrive at the arrestor depresses the lever as the leading axle rides on the ramp, and the tub is thus able to travel to the centre of the platform. By the time it is in this position, the trailing axle has released the arrestor, which springs up and prevents further movement of the tub by means of its forked end, which catches the trailing axle. The arrestor lever is arranged for a limited amount of movement, under the control of heavy helical springs, in either direction along the centre-line of the rail track. The shock of stopping the tub is absorbed by these springs, which allow for bounce as the tub comes to rest. In its rest position the tub is in the centre of the weighing platform with its leading axle ahead of the arrestor fork, and with its trailing axle between, but out of contact with, the two arms of the fork.

As the tub arrives on the platform its side makes contact with a roller on the end of a lever projecting from a switch fixed on the wall of the weigh office. Operation of this switch starts the weighing and totalising cycle, which then proceeds automatically. When the weighing and totalising have been done, the tub remains on the weighing platform until the next tub comes along the track from the pithead. This tub depresses the arrestor lever with its leading axle, thus releasing the weighed tub, which it pushes off the platform and sends on its journey to the tipplers. The second tub is then caught by the arrestor in exactly the same way as the first one, and the weighing and totalising cycle starts again (Fig. 3).

INDICATION OF INDIVIDUAL WEIGHTS

The weigh-office adjacent to the weighing platform houses a sheet-steel cabinet containing the weighing mechanism and the totaliser. Of the weighing mechanism little need be said, except that it is of the heavy shock-resisting pattern which has been made by Henry Pooley and Son, Limited, for a number of years. It incorporates the makers' standard tare arrangement, a graduated tare bar and sliding poise weight, which can be set at any position between zero and 1 ton, the divisions on the bar representing 28 lb. each. By this means the tare weight of the tubs is counterbalanced, leaving only the net weight of the contents to be weighed and totalised. The tubs which are of steel, of uniform size and design, are standardised in weight and this figure, 11 cwt., is set on the tare bar. No alteration of the tare setting is therefore necessary, and the tare bar is enclosed and kept locked, to prevent unauthorised interference. A glazed window is provided so that the setting can be observed at any time (Fig. 4).

Net weight of each load is indicated by a pointer on a circular chart 18 in. in diameter, graduated from zero to 3 tons by 28 lb. divisions, and each weighing is added to the previous total automatically, the new total being indicated by the totaliser. This unit is mounted above the weighing mechanism, and has a circular scale indicating from zero to 1 ton by 14-lb. divisions, and a six-figure counter which indicates tons. A hand-operated re-set enables the totaliser to be set to zero at any time, as required.

SEPARATE WEIGHING AND TOTALISING MOVEMENTS

The totalising mechanism consists, basically, of a mechanical counter of the type common in general engineering practice. One revolution of the pointer on the dial represents one ton, and when this revolution has been made, the units figure on the counter is moved automatically through one-tenth of a revolution. After one revolution of the units figure the tens figure is moved through one-tenth of a revolution, and so on through the whole range of figures, which in this case represents 999,999 tons.

The totaliser is independently power driven, and a special mechanism is incorporated to enable weight measurements to be transmitted to the totaliser. It is essential that the weighing resistant shall be free from contact with any form of counter or other mechanism during the actual weighing movement. The weighing resistant is highly sensitive, and must be allowed to take up its position freely according to the weight on the platform. Physical contact with any other mechanism during weighing would affect its accuracy.

The spindle carrying the weight-indicating pointer is therefore mounted coaxially with a clutch mechanism and a transposing unit, which is driven by an electric motor and which, in turn, drives the totaliser by means of a roller chain. The transposing unit is normally de-clutched, to allow the weighing spindle to move freely. When a tub arrives on the weighing platform it makes contact with the switch previously mentioned, and this, through relays and contactors, starts the totalising motor. The transposing unit, which is driven by a crank, connecting rod, toothed sector and pinion, then moves freely to the extreme forward limit of its travel. Meanwhile, the weighing spindle moves until a condition of equilibrium is reached between the weighing resistant and the load on the platform, and the net load is indicated on the dial. As the motor continues to run, the toothed sector reverses the direction of movement of the transposing unit, and it commences its return to the starting position. Immediately after this return movement begins, a cam and push-rods engage the clutch, and the transposing unit is clutched to the weighing spindle, which is driven back to zero. At the same time, the totaliser is driven by the chain from the transposing unit. The movement of the weighing spindle back to zero is over exactly the same distance as its movement from zero to a position of equilibrium, and this movement is shown, by means of suitable gearing, in terms of net weight on the totaliser. This arrangement of the two parts of the mechanism ensures that the weighing and totalising movements are completely separated until after the weighing resistant has settled freely in a position representing the true net weight of the load.

At the end of the totalising cycle the motor is stopped by a cam-operated switch, leaving the weighed and totalised tub on the weighing platform ready to be pushed off by the next tub to arrive, and the weighing mechanism ready to start the next cycle. A separate six-figure counter is operated at the same time as the totaliser, to count the number of cycles, or in other words, to record the number of tubs weighed.

Nothing further can happen until another tub arrives at the weighing platform. Should there be any delay, the weighing and totalising machine remains idle, and the weighed tub is left stationary on the platform until another tub comes along the track to depress the arrestor lever and start the cycle once more. The equipment is capable of weighing and totalising one tub every 12 seconds, which is faster than is actually required, and it adapts itself to any speed below the maximum by remaining idle as required.

At the beginning of a winding shift it is only necessary to switch on the power to the totaliser, and let the first tub gravitate to the weighing platform; operation is then automatic. At the end of the shift the last tub to be weighed will remain on the platform, and it is then necessary to depress the arrestor lever manually and push the tub on to the track leading to the tipplers. This is the only time manual attention is needed.

* * *

MECHANISED MARSHALLING YARD

Modernisation in Scottish Region

Simultaneously with the publication of the Railways plan for modernisation, containing references to the proposed large-scale alterations to marshalling yards and reported on page 102 last week, information was released about progress on the new yard near Thornton (Fife) in the Scottish Region. To cost £1,350,000 and occupy 65 acres, 15 miles of the total of 27 miles of sidings have now been laid.

The yard will be equipped with primary and secondary rail brake retarders (compressed-air operated), automatic speed control, and pre-selection route setting of points actuated through electric relays. The internal layout will consist of six reception sidings with a hump-engine rounding line arranged in tandem with 35 through sorting sidings, each of which will hold 55 wagons. Eventually, the new yard will have a capacity sufficient to deal with 3,000 wagons daily. Locomotive requirements will be met by the provision of a 70-ft. electrically operated turntable, ash pit and two water columns.

Construction of this yard is the third and largest stage of marshalling-yard development begun in the Fife area within recent years. The site is on the Dunfermline-Thornton route, approximately two miles west of Thornton Junction. It is close to the new Rothes Colliery now being developed by the National Coal Board, and will ultimately replace the separate groups of sidings which at present serve the area but which cannot be satisfactorily extended and modernised.

Interior of the mobile demonstration unit; at the front of the left-hand bench is the radio-activity meter for use in schools and colleges; on the right-hand bench are the package monitor and the beta gauge.

ISOTOPES IN INDUSTRY

INSTRUMENTS FOR LABORATORIES, SCHOOLS AND FACTORIES

Radio-active isotopes can be used for many peaceful purposes, in the laboratory, in medical research and treatment, and in industry. Equipment using radio-active isotopes is as yet scarce, and many potential users may not have sufficient opportunity to see the instruments or realise what they can do. To make the potentialities of such instruments known all over the United Kingdom and in Europe, Isotope Developments, Limited, Beenham Grange, Aldermaston Wharf, near Reading, have recently equipped a Fordson two-ton truck as a demonstration van. The van carries a selection of instruments for use in industry, in laboratories, and in schools and technical colleges; it is completely self-contained, and generates its own electricity supply if no suitable mains supply is available.

A general view of the instruments demonstrated is shown in the accompanying illustration. In addition to ratemeters and scalers for counting rates over a wide range, there are three particularly interesting items, one for use in schools and the other two in industry. The radio-activity meter type No. 552 has been designed primarily for use in science sixth forms and in technical colleges. It consists of a beta/gamma Geiger counter and a ratemeter circuit which employs a single cold cathode trigger tube. An indication of the intensity of radiation is given by the frequency of flashes in the tube and also on a microammeter positioned above the tube. A calibration curve is supplied with the instrument for converting the reading on the microammeter to counts per second; it also affords a valuable exercise for students to work out the counts per second from the meter reading.

The beta gauge, type No. 120, is designed to measure the thickness of a continuous band of material such as paper. A method which has been used to check thickness in paper production is to cut off a specific length and weigh it. This takes time, and clearly the paper cannot be cut into strips and weighed continuously. The beta gauge employs a radio-active source and a detector unit; the paper to be gauged passes between the source and the detector, and absorbs a certain amount of the radiation. The detector unit registers the change in radiation, and by connecting the detector to a suitably calibrated meter, the thickness of the paper can be read off continuously. This gauge can be used for other materials, but the way it is applied must be carefully considered; it is clear that density, as well as thickness, will affect absorption, and there are other factors that may also have to be taken into account.

For examining correct filling on a conveyor line the package monitor, type No. 210, has been designed. This again works on the principle of absorption, in this case by the contents of the package; the arrangements must be more complicated than the beta gauge, because the packages do not pass continuously between the source and detector; the normal method is to use a light source and photocell synchronised with the package monitor. The package monitor has been used successfully for products in solid, liquid, and paste form, such as drugs, soap powders, foodstuffs, and dentifrices.

A further unusual instrument is the ionisation anemometer for measuring very low-speed air currents in the range 10 to 300 ft. per minute. A radio-active source is suspended at the centre of an openwork sphere; the air between the source and the sphere is ionised by emission from the source, and the current passing to the sphere is measured on a meter. An air current passing through the sphere will blow away some of the ions and the current reaching the sphere will decrease; by suitable calibration, air speeds can be read from the meter.

* * *

TELEVISION IN THE BOILER HOUSE

After trials at the Little Barford power station of the British Electricity Authority, Marconi's Wireless Telegraph Company, Limited, Chelmsford, are to install eight industrial television equipments at the 400-MW Willington "A" station near Derby to observe the conditions in the boiler furnaces and to supervise the water levels.

At Little Barford pulverised coal is used for firing, the fuel-air stream being ignited by pilot oil burners which are extinguished when full combustion takes place. To ascertain when this condition has been reached, a television camera, fitted with a special air and water-cooled lens, was installed in the explosion door aperture at the base of the boiler, and a control unit and monitors were fixed alongside the combined boiler and turbine control panel. In this way it was possible to follow the course of the ignition process and to detect signs of imperfect combustion. Fig. 1 shows the television camera being fixed to a mounting on the furnace and Fig. 2 the monitoring screen alongside the control panel.

The water level was similarly monitored by placing a camera near the gauge, which, as usual, was fixed high up on the boiler, the image thus obtained being transmitted to the control panel.

An important feature of this application of television is that the equipment is self-monitoring, the presence of the picture on the screen proving that the equipment is working.

Fig. 1 Marconi industrial television camera being installed for remote viewing of the furnace flame.

Fig. 2 Monitor screen of the television receiver alongside the boiler and turbine control panel.

Labour Notes

RAILWAY INQUIRY URGED

There have been indications from several directions during the last few days that it is the Government's intention to press for a thorough investigation into ways and means of obtaining increased economy and efficiency on the railways.

Opposition by the railway unions to the institution of an inquiry conducted from outside the industry became apparent very shortly after the publication of the final report of the court of inquiry into the recent wage dispute. Consequently, the court's proposals for such an inquiry are not likely to be enforced, as it is generally recognised that the co-operation of the unions is essential if the best results are to be obtained.

At the same time, neither the British Transport Commission nor the unions have shown themselves to be averse to the holding of a private inquiry within the industry and it seems probable that it is along such lines that an inquiry, if undertaken, will be conducted. An announcement by the Commission of its proposed action in the matter may be expected in the near future.

The main requirements for the success of such an inquiry appear to be that it should be held in an atmosphere of goodwill and take place immediately, so that any reforms which may be decided upon can be put into operation promptly.

COURT'S CRITICISMS

In its final report (Cmd. 9372, H.M.S.O., price 1*s.* net), the court sets out the history of the dispute between the Commission and the National Union of Railwaymen (into which it was appointed to inquire) and examines in some detail the contentions of the two parties. It also reviews the negotiations leading up to the union's decision to call a nation-wide strike on January 9 last.

The court condemns the union for repudiating the wage agreement of October, 1954, which had been ratified and was already in operation. This step the court refers to as being without precedent in railway-wage negotiations.

The union is also taken to task for stipulating, after its rejection of the October agreement, that negotiations could proceed only as a continuation of its original claim of July, 1953, and for insisting on a prior assurance of substantial concessions before discussions had even begun.

At the same time, the court criticises as being "mutually contradictory" the arguments put forward by the Commission during the negotiations and suggests that the exasperation and sense of frustration engendered by these replies partially explain what the court regards as the "extraordinary conduct" of the union. This, in the court's view, formed the crux of the dispute.

FAIR WAGES DEFINED

The court examines the financial obligations laid on the Commission by the Transport Act, 1947, which provide that that body shall balance its revenue and expenditure over a period of years.

In the light of the Commission's own statements, the court concludes that acceptance of the statutory obligations does not, by itself, operate as a bar to the payment of what may be determined to be adequate wages for efficient service, unless a situation is reached when the imposition of further burdens of expenditure makes it impossible for the Commission to achieve its duty over its chosen period of years.

The court recalls that in its interim report it expressed the view that the nation must be prepared to see that the nationalised railways were efficiently run and that the rates of wages paid to railway employees should be not less than those paid in comparable industries.

Elaborating this remark, the court states that it is implicit in all this that the wage must be properly earned, and that, to be a "fair wage," it must not only be no lower than it should be, but also no higher. The right to receive a fair and adequate wage is no more than this.

Where, as in the case of the Commission, the employer is bound to keep his business going, and can neither show a working profit, nor shift the scene of his operations, nor re-organise his capital structure, nor be wound up by his creditors, then the factors which are understood by all as affecting wage rates in normal industry are absent.

The conditions in such a business are, commercially speaking, artificial and it accordingly becomes necessary to fall back on the expedient of relating the wages that should be paid to those paid in such comparable industries as may be found.

It is fundamental, the court emphasises, that the employer is entitled to expect, and the employee is bound to give, a fair day's work for a fair day's wage.

MANPOWER PROBLEMS

Reference is made by the court in the concluding paragraphs of its report to questions of surplus manpower and to the need for improvements in economy and efficiency.

It is pointed out that both sides agree that there is room for further efforts in these directions, and that it is not claimed that problems of over-staffing or restrictive practices have been wholly or satisfactorily solved. Comment is made on the lack of enthusiasm, stated to have been shown by members of the National Union of Railwaymen, for co-operation to improve productivity, so long as what they regarded as their just claims were not met.

Mention is also made of failures in labour relations and of other causes of difficulty and disagreement which have arisen between the Commission and the union.

The present position, the court affirms, is unhappy, and it seems that the elucidation and solution of such difficultes and disagreements call for a much more searching and detailed inquiry than would have been possible for it in the light of the extraordinary circumstances in which it was called upon to act.

UNDERGROUND RAILWAY EMPLOYEES' WAGES

Delegates claiming to represent some 12,000 employees on London's Underground Railways demanded at a meeting in London last Monday that strike action should be taken within 14 days, unless claims for higher pay were to be granted previously.

This threat to London's travelling facilities came only a few hours after negotiations between London Transport Executive and the three railway unions had been re-opened. As recently as last week, discussions between the two sides were in danger of breaking down. The National Union of Railwaymen considered that progress was being made too slowly and that the talks were being conducted too much from the point of view of what was applicable to the main-line services.

A meeting between Sir Brian Robertson, chairman of the British Transport Commission, and Mr. J. Campbell, general secretary of the National Union of Railwaymen, led to last Monday's discussions between the Executive and the unions. It is understood that quite definite progress was made at these discussons and they were later adjourned until last Wednesday.

One of the difficulties that appears to have arisen is the rate to be paid to the Executive's motormen. The Executive are believed to have offered to these men, who drive electric trains on the Underground Railways, a rate somewhat less than that paid to motormen employed by British Railways. The unions are opposed to this differentiation and have pointed out that the rates have been the same over a considerable period of time.

The fact that no final agreement has so far been reached respecting the wages of engine drivers on the main-line services is an added complication.

BRITAIN'S ECONOMIC SITUATION

Consideration to the existing economic situation was given at the quarterly meeting of the Minister of Labour's National Joint Advisory Council, which took place in London on January 26, under the chairmanship of Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour and National Service.

The Council, which comprises representatives of the British Employers' Confederation, the Trades Union Congress and the nationalised industries, had before it an appreciation of the economic situation covering the three months ended November 30 last, a report covering the same period on the employment and unemployment situation on a regional basis, and the latest statistics of short-time and overtime working.

The manpower situation showed that the main trend in the movement of the country's labour force during this period, and throughout the whole of last year, had been the increase in employment in the engineering, metals, and vehicle-building industries. Increases in the numbers of persons engaged in civil employment, between November, 1953, and November, 1954, were largely concentrated in the manufacturing industries.

In these industries, rather less than half of the total manpower was employed in the engineering, metals, and vehicle-building industries, and nearly two-thirds of the total increase during the twelve months (180,000 persons out of 280,000) also took place in that group of industries. The sections principally affected were the vehicle-building and electrical-engineering industries, in each of which there was an increase of 50,000 persons during the period.

During the ensuing discussion on economic progress in 1954, the Council, although fully appreciative of the favourable advances which had been made, viewed with some anxiety the increasing pressure of competition in the export markets and expressed its sense of the precariousness of the existing situation.

WAGES INSPECTORATE

Representatives of the Trades Union Congress raised the question of the proposed reduction in the number of officials of the Wages Inspectorate and suggested that this loss of manpower would mean a reduction in the frequency of routine visits for the inspection of wage books by about one-third.

It was explained that it was the Ministry's policy to ensure that there were sufficient wage inspectors on the Inspectorate's staff to investgate all complaints of non-compliance with regulations and to maintain a reasonable measure of routine inspection.

The Ministry, it was stated, fully accepted the view that inspection must be adequate. The investigation of complaints, which represented a substantial part of the inspectors' work, would be continued. About 10,000 such cases were dealt with during 1953.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Electricity in Horticulture," by F. E. Rowland. North-East London Branch. Angel Hotel, Ilford. Mon., Feb. 7, 8 p.m.
BIRMINGHAM
"Electricity in Horticulture," with film, by M. M. Harvey. Birmingham Branch. Chamber of Commerce, 95 New-street, Birmingham. Wed., Feb. 9, 7.15 p.m.
YORK
"Industrial Lighting," with film, by R. Pye. York Branch. Picture House Café, Coney-street, York. Wed., Feb. 9, 7.15 p.m.

British Institution of Radio Engineers

GLASGOW
"Radio-Telephone Systems to the Islands," by T. Moxon. Scottish Section. Institution of Engineers and Shipbuilders, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Feb. 10, 7 p.m.
NEWCASTLE-UPON-TYNE
Students' papers. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Feb. 9, 6 p.m.
WOLVERHAMPTON
"Electronic Motor Control Systems," by J. C. Rankin. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Feb. 9, 7.15 p.m.

Chemical Society

BRISTOL
Hugo Muller Lecture on "Some Newer Aspects of the Organic Chemistry of Nitrogen," by Professor G. R. Clemo. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Feb. 10, 7 p.m.
EXETER
"A Topic in Alkaloid Chemistry," by Professor G. R. Clemo. Exeter Branch. Washington Singer Laboratories, Exeter. Tues., Feb. 8, 5 p.m.
HULL
"Chromatography," by Dr. T. I. Williams. Hull Branch. The University, Hull. Thurs., Feb. 10, 6 p.m.
NEWCASTLE-UPON-TYNE
"The Place of Theoretical Chemistry in Chemical Education," by R. P. Bell. Newcastle and Durham Branch. Chemistry Building, King's College, Newcastle-upon-Tyne. Fri., Feb. 11, 5.30 p.m.
NOTTINGHAM
"Melting and Crystal Structure," by Professor A. R. Ubbelohde. Nottingham Branch. The University, Nottingham. Thurs., Feb. 10, 4.45 p.m.
ST. ANDREWS
"Organic Chemistry of Phosphorus," by Professor H. N. Rydon. St. Andrews and Dundee Branch. Chemistry Department, The University, St. Andrews. Fri., Feb. 11, 5.15 p.m.

Illuminating Engineering Society

LONDON
"Lighting of Hazardous and Corrosive Locations in Industrial Plants," by A. G. Palmer and W. E. Harper. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Feb. 8, 6 p.m.

Incorporated Plant Engineers

EDINBURGH
"Foundations for Buildings and Machinery," by A. Mason. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Feb. 8, 7 p.m.
MANCHESTER
"Electronic Control in Industry," by J. E. Fielden. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Feb. 8, 7.15 p.m.
NEWCASTLE-UPON-TYNE
"Fuel-Injection Equipment," by H. J. Stoneman. North-East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Feb. 10, 7 p.m.
NOTTINGHAM
"Changing Bad Ions for Good," by F. C. H. Taylor. East Midlands Branch. Adult Education Centre, Shakespeare-street, Nottingham. Wed., Feb. 9, 7 p.m.

Institute of British Foundrymen

GLASGOW
"Some Aspects of Steel-Foundry Practice," by H. Hart. Scottish Branch. Royal Technical College, Glasgow. Sat., Feb. 12, 3 p.m.
LINCOLN
Open Discussion on "Foundries." Lincolnshire Branch. Technical College, Lincoln. Thurs., Feb. 10, 7.15 p.m.
LUTON
Discussion on "Gadgets," introduced by E. Daybell. Bedfordshire and Hertfordshire Section. Town Hall, Luton. Thurs., Feb. 10, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Production of Heavy Steel Castings," by S. Taylor. Newcastle Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Sat., Feb. 12, 6 p.m.
SHEFFIELD
"Bell Founding," by M. Howard. Sheffield Branch. College of Technology, Pond-street, Sheffield. Mon., Feb. 7, 7.15 p.m.

Institute of Fuel

LONDON
"Wales Gas Board: Integration of Fuel Supplies," by E. M. Edwards, W. T. Hird, S. L. Wright and T. S. Ricketts. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Feb. 10, 5.30 p.m.
MANCHESTER
"The Acid Dew-Point," by J. R. Rylands and J. R. Jenkinson. North-Western Section. Engineers' Club, Albert-square, Manchester. Wed., Feb. 9, 6 p.m.

Institute of Marine Engineers

LONDON
"Practical Approach to Some Vibration Problems in Ships," by T. W. Bunyan. Tues., Feb. 8, 5.30 p.m.
BIRMINGHAM
"Design and Operation of Nuclear Power Stations," by Dr. H. S. Arms, at 7.30 p.m. Preceded by the Annual General Meeting, for members only, at 6.45 p.m. West Midlands Section. Imperial Hotel, Birmingham. Thurs., Feb. 10.
GLASGOW
"Design and Construction of a 10,000-ton Cargo Ship," by J. Baird, at 7.45 p.m. Preceded by the Annual General Meeting, for members only, at 7.30 p.m. Scottish Section. 39 Elmbank-crescent, Glasgow, C.2. Wed., Feb. 9.
KINGSTON-UPON-HULL
"The Significance of Apparently Minor Factors in Corrosion Problems Affecting Condenser and Cooler Tubes," by Clifford Breckon and J. F. T. Baines. Kingston-upon-Hull and East Midlands Section. Royal Station Hotel, Kingston-upon-Hull. Thurs., Feb. 10, 7.30 p.m.
LIVERPOOL
"Observations on Marine Gearing," by J. Rogerson. Mersey-side and North Western Section. 9 The Temple, 24 Dale-street, Liverpool. Mon., Feb. 7, 6.30 p.m.

Institute of Metals

SWANSEA
"Tool and Die Steels," by E. Johnson. South Wales Local Section. University College, Singleton Park, Swansea. Tues., Feb. 8, 6.45 p.m.

Institute of Petroleum

LONDON
"Applicational Research in the Petroleum Industry," by Dr. C. G. Williams. Wed., Feb. 9, 5.30 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
"Road and Rig Testing of Prototype Road-Transport Vehicles and Their Components," by John Alden. Midlands Centre. Crown Inn, Broad-street, Birmingham. Tues., Feb. 8, 5.30 p.m.
BRISTOL
"Paint-Synthetic Resins and Wet-on-Wet Spraying," by C. Butler. Western Centre. Grand Hotel, Bristol. Wed., Feb. 9, 7.30 p.m.
CARDIFF
"Plastics and Their Use in the Road-Transport Industry," by A. Jones. South Wales Group. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Feb. 10, 7 p.m.

Institute of Welding

LONDON
"Typical Details for Welded Building Structures," by H. Roscoe. South London Branch. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Thurs., Feb. 10, 6.30 p.m.
EDINBURGH
"Hard Surfacing of Ferrous Metals," by M. Riddihough. East of Scotland Branch. Chamber of Commerce, Charlotte-square, Edinburgh. Wed., Feb. 9, 7 p.m.
PRESTON
"Liquefaction of Gases," by F. Din. Preston Branch. Harris Technical College, Corporation-street, Preston. Wed., Feb. 9, 7.15 p.m.
SHEFFIELD
"Developments in Oxy-Acetylene Welding," by R. L. Fannon. Sheffield Branch. College of Commerce and Technology, Sheffield. Mon., Feb. 7, 7.15 p.m.

Institution of British Agricultural Engineers

LONDON
"Effects of Mechanical Treatment on the Drying Rate of Hay in the Field," by F. S. Mitchell and G. Shepperson. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Feb. 8, 2.15 p.m.

Institution of Chemical Engineers

LONDON
"The Mechanism of Drying of Solids," by E. W. Bruce, R. F. Strickland-Constable and Professor D. M. Newitt. Geological Society's Apartments, Burlington House, Piccadilly, W.1. Tues., Feb. 8, 5.30 p.m.

Institution of Civil Engineers

LONDON
"The Effect of 'Storage' on Sewerage Design," by C. D. C. Braine. Public-Health Engineering Division. Tues., Feb. 8, 5.30 p.m.
BIRMINGHAM
"Shuttering and Concrete," by S. G. Boosie. Midlands Association. James Watt Memorial Institute, Birmingham. Thurs., Feb. 10, 6 p.m.
HULL
"Some Aspects of Flood Control," by W. F. Gilbert. Yorkshire Association. Electricity Showroom, Ferensway, Hull. Wed., Feb. 9, 6.15 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Radio Interference," opened by C. W. Sowton. Mon., Feb. 7, 5.30 p.m.
"A Study of Commercial Time Lost on Transatlantic Radio Circuits Due to Disturbed Ionospheric Conditions," by J. K. S. Jowett and G. O. Evans; and "Performance Characteristics of High-Frequency Radio Telegraph Circuits," by A. M. Humby, C. M. Minnis and R. J. Hitchcock. Radio Section. Wed., Feb. 9, 5.30 p.m.
"Maintenance Principles for Automatic Telephone-Exchange Plant," by R. W. Palmer. Thurs., Feb. 10, 5.30 p.m.
BIRMINGHAM
"District Heating," by J. Armstrong; "Modern Electrical Methods of Balancing Machines," by E. P. Fowler; and "The Planetry Mill and Its Drive," by J. T. Jones. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Feb. 7, 6 p.m.
BRIGHTON
"A Criterion of Distribution Cost," by D. J. Bolton. Southern Centre. Brighton Technical College, Brighton. Wed., Feb. 9, 6.30 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"Modern Turbo-Alternators," by P. Richardson. North-East Branch. 6 Higham-place, Newcastle-upon-Tyne. Mon., Feb. 7, 7.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Paddlewheel Research. Part 1: Preliminary Model Experiments," by H. Volpich and I. C. Bridge. Tues., Feb. 8, 7.30 p.m.

Institution of Heating and Ventilating Engineers

CARDIFF
"Impressions of American Practice," by L. Copeland Watts. G.E.C. Building, Cardiff. Tues., Feb. 8, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
"Running-in of Engines: Choice of Cylinder-Bore Finish," by K. R. Williams and Dr. S. G. Daniel. Automobile Division. Tues., Feb. 8, 5.30 p.m.
Discussion on "Use of Models." Allied Mechanics Group. Wed., Feb. 9, 6.45 p.m.
"Effects of Velocity and Temperature of Discharge on Shape of Smoke Plumes from a Chimney or Funnel," by L. W. Bryant and C. F. Cowdrey. Fri., Feb. 11, 5.30 p.m.
BEDFORD
"Aspects of Aircraft Design," by A. Newall. Eastern Branch. Dujon Restaurant, Bedford. Thurs., Feb. 10, 7.30 p.m.
BRISTOL
"Welding and Fabrication," by F. G. C. Sandiford. Western Branch. Grand Hotel, Bristol. Tues., Feb. 8, 7 p.m.
GLASGOW
Thomas Lowe Gray Lecture on "Factors in the Selection of Machinery for Cargo Liners," by Commander (E) L. Baker. Scottish Branch. Royal Technical College, Glasgow. Thurs. Feb. 10, 7.30 p.m.
LEEDS
"Rolls-Royce RM60 Marine Gas Turbine," by A. H. Fletcher and R. W. Corbett. Yorkshire Branch. The University, Leeds. Thurs., Feb. 10, 6.30 p.m.
LIVERPOOL
Thomas Lowe Gray Lecture. North-Western Branch. 9 The Temple, 24 Dale-street, Liverpool. Wed., Feb. 9, 6 p.m.
NEWCASTLE-UPON-TYNE
Thomas Lowe Gray Lecture. North-Eastern Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Feb. 7, 6 p.m.

Institution of Production Engineers

COVENTRY
"Production of Precision Involute Gears," by W. T. E. Golding. Coventry Section. Craven Arms, High-street, Coventry. Tues., Feb. 8, 7 p.m.
LEICESTER
"Design and Manufacture of Portable Electric Works," by C. H. Gubbins. Annual General Meeting. Leicester Section. Bell Hotel, Leicester. Thurs., Feb. 10, 7 p.m.

Institution of the Rubber Industry

LONDON
"Automatic Control in the Rubber Industry," by E. R. Amery; and "Whiting and Other Calcium Carbonates Used as Fillers in Rubber," by G. E. Bessey. 26 Portland-place, W.1. Tues., Feb. 8, 5.30 p.m.
NEWCASTLE-UPON-TYNE
"Rubber Machinery," by K. Bradshaw. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Feb. 7, 7 p.m.

Junior Institution of Engineers

LONDON
"Underground Water," by K. G. Benham. Fri., Feb. 11, 7 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Temperature Measurements on Marine Diesel Engine Pistons," by Professor J. A. Pope and Dr. J. Fitzgeorge. Neville Hall, Newcastle-upon-Tyne. Fri., Feb. 11, 6.15 p.m.

Royal Aeronautical Society

COWES
"Rocket Propulsion for Aircraft," by Professor A. D. Baxter. Isle of Wight Branch. Saunders-Roe Club House, Cowes, Isle of Wight. Thurs., Feb. 10, 7 p.m.

The Royal Society

LONDON
"Research Activities of Grubb Parsons," by G. M. Sisson. Thurs., Feb. 10, 4.30 p.m.

Society of Engineers

LONDON
Presidential Address by Dr. H. G. Taylor. Geological Society's Apartments, Burlington House, Piccadilly, W.1. Mon., Feb. 7, 5.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of British Agricultural Engineers, 24 Portland-place, London, W.1. (LANgham 3394.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)